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EDITED BY W. S. DALLAS, F.L.S.
ASSISTANT-SECRETARY OF THE GEOLOGICAL SOCIETY.

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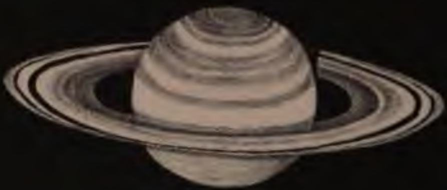

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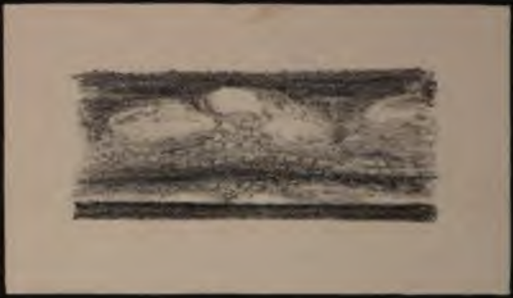

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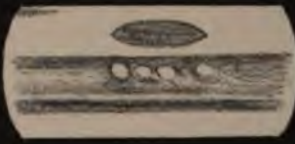

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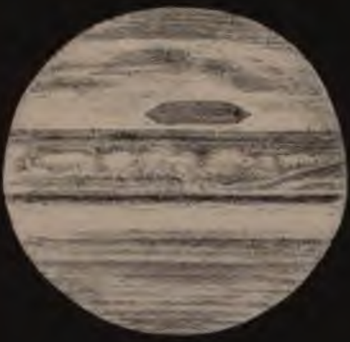

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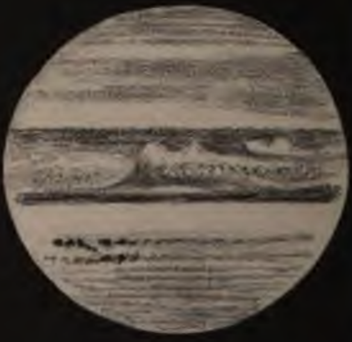

Fig. 2.

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JUPITER & SATURN IN 1880. OCT & NOV.

POPULAR SCIENCE REVIEW.

THE PLANET JUPITER IN OCTOBER AND NOVEMBER, 1880.

By W. F. DENNING, F.R.A.S.

[Plate I.]

FROM remote ages, long before the period when the Chaldæan shepherds began something like a systematic survey of the heavens, the brightness and conspicuous aspect of the Jovian planet has continued to attract the attention and admiration of mankind. Whilst the Chaldæans introduced their nomenclature of the constellations, and placed a variety of figures and forms in the sky to inaptly represent the curious groupings of the stars, this planet must have been the brilliant spectator of the work. Belonging, as he did, to the class of 'wandering stars,' it was impossible to limit HIM to any definite region of the sky, and to give him an enduring place amongst the variety of imaginative titles which were then affixed to the stars. Shining with surpassing lustre, and with a unique steadiness in remarkable contrast to the scintillations of the stellar orbs, we need not wonder that many inquiring glances were directed to him, and many speculations hazarded as to his physical aspect, and the special purpose he was designed to fulfil in the scheme of creation. At that day men were all unconscious of the marvellous system which, in after times, the telescope revealed. They could have little conception of the wonders which delighted the eye of Galileo in January 1610, when he first beheld the *Medicean stars*, as he called the four satellites, and watched their revolutions as they upheld the Copernican system of the Universe, and unfolded a host of new facts to his gratified understanding.

Since Galileo's time nearly three centuries have rolled away. Astronomical science has marched onwards with a rapid pace, ever accumulating fresh knowledge and perfecting its appliances of research. The puny, incompetent telescopes of former times have been supplanted by the giant instruments of Herschel, Rosse, Lassell, and others, which have been employed to search out new items of discovery, and to bring to light new orbs from almost fathomless space. The Jovian planet has always been the subject of special attention. His system of attendant moons, and the singular belts of shading which diversify his globe, have been observed again and again: and one of the most important facts gleaned from such observations was that of the extreme swiftness with which objects were carried across his surface, and the resulting inference that the length of his day was very much shorter than ours. Cassini had, as early as 1665, determined the period as $9^h\ 56^m$, and this conformed with remarkable precision with determinations of more recent date by Maraldi, W. Herschel, Schröter, Mädler, and others, who gave slightly differing values, averaging $9^h\ 55\frac{1}{2}^m$. The method of proceeding in each case was to observe certain dark spots as they were successively presented on the same points of the planet's surface, when, by noting the exact intervals which elapsed between their reappearances, the period of rotation became readily ascertainable. The slight discordances apparent in the values independently assigned by the several observers could be explained on ordinary grounds. The spots may not in all cases have been subject to the same conditions. Some of them may have exhibited proper motion, which must have clearly originated such discrepancies.

In the summer of 1878 a dark elliptical spot of considerable dimensions and very striking character made its appearance on the surface of *Jupiter*. It was situated just south of the great equatorial belt of the planet, and it still remains visible, forming a most frequent and interesting object for telescopic examination. It displays the same intensely red colour as the adjoining dark belts, and appears likely, from the constancy of form and distinctness of outline which it invariably exhibits, to remain perceptible for a lengthened period. No one can possibly foresee the date of its final disruption and disappearance, because we are ignorant of the conditions under which it exists, and of the influences to which it is subject. Of its origin we also know little or nothing. It was already a conspicuous object, displaying an intense rosy hue, when first discovered by Prof. Pritchett at Missouri on July 9, 1878. In fact, the spot does not appear to have been traced in the early stages of its formation, so that it cannot be said the process was gradual, and that the object, first becoming visible as a minute speck, went on enlarging and intensifying until it reached its present striking proportions. The spot may quite possibly have resulted from a sudden convulsion in the Jovian atmosphere, by which a large area was sundered, d the planet's dark surface in part revealed. In any case, seemingly permanent character of the spot and its well-marked *e are its* most salient features; and should indications either of decay or further development be presented, they will be quickly noticed by the host of observers who are engaged in watching what is certainly one of the most singular and attractive of the astronomical phenomena of our time.

Some important purposes will be served by the long endurance of this unique object. It will give us the means of computing, with greater facility and accuracy than was ever attempted before, the period of rotation of *Jupiter*. This has been already attempted with some success, and the resulting values in two instances are $9^h\ 55^m\ 34^s{\cdot}2$ and $9^h\ 55^m\ 33^s{\cdot}9$. These were derived from observations during the opposition of 1879, and they show that the period of $9^h\ 55^m\ 26^s$, which has been commonly adopted hitherto, is fully 8 seconds short of the true interval. But though the new determination of $9^h\ 55^m\ 34^s$ above referred to may be relied on as extremely exact, it should be suggested that the work has been undertaken prematurely. It is advisable not to be too sanguine of results depending on short periods, however carefully the details have been worked out. The final discussion of the question must be left to a future time, for it will be obviously preferable to rely on a period extending over several years than on a period extending over a few months only. The planet, as observed on two dates, say four months apart, has performed less than 300 rotations, whereas, if the interval is extended to four years, the number of rotations will be more than 3500; and seeing that the large spot now visible is likely to endure for a period at least equal to this, we can well postpone the ultimate analysis to the time immediately preceding the end of its visible existence. We shall then be enabled, by a comparison of a few of our best observations, to deduce the period with more precision than could result from a mere partial investigation.

But just as astronomers had been congratulating themselves upon such excellent means of finding the length of the Jovian day, we had the announcement that the markings upon the disc of the planet are influenced by a variety of different motions. The great red spot, which has created so much stir amongst observers of planetary phenomena, cannot keep pace with the white spots which alternate with the darker areas around the shaded equatorial girdle of the planet, nor do the black spots of smaller type (some varieties of which have lately been spread along a faint belt in the north hemisphere) maintain permanent positions, either with respect to each other, or to the other markings on the surface. In fact, as observed on different nights, the appearance of the planet is vastly altered; a series of rapid currents, probably atmospheric, has displaced the relative positions of the chief objects. While the great red spot in the *southern hemisphere* makes its regular apparitions at periods of $9^h\ 55^m\ 34^s$, the white equatorial spots are only $9^h\ 50\frac{1}{4}^m$, and the black spots in the north hemisphere only $9^h\ 48^m$. The smaller spots have, therefore, a swift proper motion from west to east around the planet, and they have been seen, on several consecutive nights of observation, to overtake the red spot, to pass rapidly by it, and then to precede it by a distance increasing with every successive epoch. These facts are thoroughly well authenticated by the accordant results of several diligent observers.

That phenomena of such striking aspect and indicative of stupendous changes in the atmospheric envelope of the planet should have so long escaped the frequent and vigilant scrutiny its importance greatly demanded, is very surprising when we consider the host of adequately powerful telescopes which are again and again directed to *Jupiter* at each recurring opposition. For there is no sufficient reason to think that the curious details recently observed are of very rare character, and special to our own time. Notwithstanding their present very distinct and palpable occurrence, we have every right to assume that they are the simple evidence of what is constantly manifested in the physical aspect of the planet. Look at him whenever we will, we shall find some indications of vast disturbances, and (though there may be times of comparative quiescence in such phenomena) they will occasionally be so conspicuous as to call for particular comment. But the more minute of these appear to have eluded observers in past years, and it is only now that the apparition of the great red spot has so fully aroused interest that they seem likely to receive a full investigation. We shall certainly learn something of the singular phenomena occurring on the planet by their means. The complexity of spot-motion which the observations are unfolding, have their explanation; and this may be forthcoming when the results come to be collated and compared in the final analysis.

We have said that former observers had overlooked these important facts. We mean by this that the matter had never been discussed with any thoroughness, and that, though we may find amongst old records some brief, vague references to phenomena similar to those which are now engaging so much notice, they never received a due meed of attention. We can go back, indeed, more than two centuries, and trace what may have been a precisely similar observation to what is now recorded. Cassini, in 1665, determined the rotation period of *Jupiter* as $9^h\ 56^m$; and seven years later, from other spots which he distinguished, at $9^h\ 55^m\ 50^s$. These results, so nearly coincident, were evidently derived from markings of analogous character to each other, and to the red spot which is at present visible on the planet. Twenty years later, namely in 1692, Cassini observed another spot, whose motions he watched with the same assiduity as in the preceding instances, and deduced a period of $9^h\,50^m$ from his new observations. The inference is obvious. He had observed objects of different nature, showing a difference of motions, for the discordance of nearly six minutes between his values cannot possibly be accounted for on other grounds. The trivial discrepancy of 10 seconds between his first two values is readily explained by errors of observation; but the large disagreement with his subsequent calculations is only to be satisfied on the assumption that the spot exhibited proper motion.

Schröter has also left on record an observation of black spots crossing the Jovian disc in abnormal periods; and Mädler, in his *Populare Astronomie* has a reference to similar phenomena.

In September, 1880, the writer commenced a series of observations of *Jupiter*, with the object of noting the peculiar forms of the markings, and of generally recording such changes as might be presented in his appearance. The telescope employed was a reflector of 10 inches aperture, by Browning of London. The powers used depended upon the state of the atmosphere. Sometimes the performance of the instrument was best with 300, but under ordinary circumstances 450 was the most effectual; and at times, when the air was very steady and the planet free from that tremulous movement so annoying to observers, 500, and even 600, could be used with advantage. The usual appearance of the planet was that of a globe striped with a variety of dark parallel bands. Whenever the large spot was visible, the aspect was different. Its well-defined outline and the contrast it offered to the series of continuous belts, gave a special character to the view (Pl. I. fig. 1). In the equatorial region of the planet, there was always a very broad and variously marked zone of shading. A mass of detail was apparent here, and changes of great extent were evidently in progress. The zone was bounded, on both its north and south limits, by a dark streak, that on the north side being obviously the deeper of the two. Included within these streaks, there were fainter patches interspersed with lighter areas and spots. The latter were usually slightly on the southern side of the equator, while, immediately on the other side and contiguous to the north streak, though distinct from it, was an irregular row of dusky patches. In the southern hemisphere, the great spot was visible adjacent to the great belt (see Fig. 1), and preceding this to the southward, there lay a smaller elliptical spot, which was discovered by Mr. Barnard, at Nashville, Tennessee, on July 24th, 1880. Several faint belts were perceptible on the south side of these objects, and the south pole itself was capped by a dusky shadowing, or by a numerous array of belts so close together as to be inseparable. In the northern hemisphere, more belts were generally distinguished than in the southern; and one of these, [illegible] zone, was always very plain and [illegible]. After the middle of October it became indeed an object of peculiar interest, for it exhibited a series of dark spots and patches, which developed so rapidly and moved with such velocity as to give the most distinct evidence of phenomena of marvellous character. The first signs of the disturbance appear to have been noticed by Mr. Dennett, at Southampton, at midnight on October 17th, when two dark spots were seen just past the central meridian [illegible], and in north latitude about 25°. These soon became much more conspicuous, others formed and they spread out to such an extent that at the present time they extend fully half-way round the planet, though at the time of their discovery they were separated by an interval not exceeding some 20° of longitude. The writer first noticed the disturbed state of the belt on the night of October 24th, at 11¼ p.m., when a train of dark spots was visible on the west limb (see Pl. I. fig. 2). They were detected again on October 29th and subsequent nights, and the individual spots of the group were recorded as they crossed the central meridian of the planet. To show how quickly the spots extended themselves along the belt, let us compare the periods occupied by the whole group in passing the meridian:—

	h m		Deg. of Long.
Oct. 29	0 53	...	32·0
Nov. 2	1 27	...	52·6
Nov. 8	1 50	...	66·5
Nov. 23	3 19	...	120·3
Nov. 27	4 21	...	157·8

These spots soon gave indications of proper motion. Their period of rotation was about 7½ minutes less than that of the great red spot, in fact, between October 29th and December 2nd, a comparison of their positions shows them to have made a complete circuit of the planet! They had only occupied 34 days in traversing the vast extent of the Jovian sphere. A further development of the spots in the same longitudinal direction will soon have the effect of entwining them completely around the planet; and such appears to be the inevitable result of their recent behaviour. We may then expect to see their gradual disappearance as distinct spots, though they may possibly be perceptible for a long time afterwards under the character of a very conspicuous belt lying north of the equator. If this eventually proves to be the case, and the future appearances of the spots should be critically watched to ascertain whether it is shall have a good instance as to how these large belts are The inference will be that they are originated by an uprush, or emission, from the planet's surface; and that as this reaches the outer regions of the atmosphere it is dispersed in the direction of the longitude by the effects of the rapid rotatory motion of the planet. It is certain that these small spots are different in some essential details from the large spot in the southern hemisphere, inasmuch as they display a very erratic form of appearance and rate of motion, and are probably to be accounted for in a totally different manner. On the other hand, the minute elliptical spot, south preceding the red spot, has, by its constancy of position, sufficiently proved itself to be of analogous character.

We have mentioned light patches and spots as discernible in the southern interior border of the great equatorial belt, and there is one of these which should be singled out as displaying a more prominent aspect than any of the others. It was first seen by the writer just before midnight on September 18th, when the following reference was entered in his note-book:—

'1880. September 18th, 11ʰ 50ᵐ, observed *Jupiter* with 10-inch reflector, power 150; but there were storms and clouds which interrupted, though the planet was fairly well defined at times. I noticed a bright spot directly, about half way across the disc and just south of the equator. Another bright, elliptical spot preceded this, and indeed on the equatorial borders of the great southern belt the surface was very bright in places, giving the impression of more objects of similar kind. The chief spot had a pearly whiteness and stood out with conspicuous plainness amongst the mass of detail faintly traceable along the planet's equator.'

I took particular care to re-observe this curious appearance as often as possible during the ensuing months of October and November, and to note, with as much accuracy as eye-estimates permitted, the exact times when it crossed the central meridian of *Jupiter*. The following results were thus obtained:—

	h	m	Long. °		h	m	Long. °
Sept. 18	11	50	85·8	Nov. 19	9	23	339·4
Oct. 20	11	38	221·9	Nov. 20	5	2	332·3
Oct. 30	7	28	137·5	Nov. 21	10	41	327·8
Nov. 2	14	15	115·6	Nov. 26	8	44	289·9
Nov. 3	9	47	104·2	Nov. 27	4	19	280·2
Nov. 4	5	25	96·4	Nov. 28	9	51	271·4
Nov. 8	7	48	65·4	Nov. 29	5	27	262·4
Nov. 17	8	14	356·7	Dec. 3	7	54	233·4

Thus in 76 days the spot had apparently traversed 572°·4 of Jovian longitude, which is equivalent to 7°·5 per day. This is with reference to the assumed position of the first meridian, which is based on a period of $9^{h}\ 55^{m}\ 27^{s}{\cdot}08$, derived from the observations of dark spots seen in 1834–5 and 1862. But if the motion of the white spot is taken relatively to that of the red spot now visible, which rotates more slowly than those of 1834–5 and 1862, referred to, it becomes even greater; for during the eleven weeks over which the observations extend, the aggregate movement will be 586°, or 7°·7 daily = nearly 13 minutes of time. This motion has not been uniformly maintained. The records show a considerable retardation during the latter period of the observations. Let us divide the dates into nearly equal intervals and compare the calculated periods from each of them :—

	h m		Observed period. h m s
Oct. 20 . .	11 38	24 rotations ...	9 49 35
Oct. 30 . .	7 28		
Oct. 30 . .	7 28	22 rotations ...	9 50 0
Nov. 8 . .	7 48		
Nov. 8 . .	7 48	22 rotations ...	9 50 16
Nov. 17 . .	8 14		
Nov. 17 . .	8 14	22 rotations ...	9 50 27
Nov. 26 . .	8 44		

Between November 26th and December 3rd, the motion seems to have been accelerated, the period being $9^{h}\ 50^{m}$, exactly, and similar to that of the period from October 30th to November 8th.

Certain trivial, though important, corrections have to be applied to these times. Differences in the longitudes of *Jupiter* and the Earth, and in the varying distance and phase of the planet have severally to be computed and the resulting values applied to the simple observed periods. But the corrections required are very small, not exceeding a few seconds, and will be properly discussed when the observations have reached a more complete stage and are in process of final reduction.

In Fig. 3 (Pl. I.), I have endeavoured to show the appearance of the white spot in the equatorial belt on November 28th, when it was noted as central on *Jupiter*. Compared with the dark rifts and streaks in its vicinity, the spot is strikingly prominent, lying a little south of the equator and breaking into the great south belt. In Fig. 4 are shown its several positions as it overtook the red spot on the nights of November 17th, 19th, 20th, and 21st. On November 19th, the white spot appeared to be situated in precisely the same longitude as the red spot. On the following night its swifter motion had carried it forward considerably in advance of the middle of the red spot, and on November 21st it was perceptible under the preceding end. The following is the comparison of the observed times of transit of these spots and the differences which their discordant motions have originated :—

Date.	Red spot.		White spot.		Difference.		
	h	m	h	m		h	m
Nov. 2	10	26	14	15	+	3	49
Nov. 3	6	12	9	47	+	3	35
Nov. 8	5	21	7	48	+	2	27
Nov. 17	7	44	8	14	+	0	30
Nov. 19	9	23	9	23	+	0	0
Nov. 20	5	14	5	2	–	0	12
Nov. 21	11	4	10	41	–	0	23
Nov. 27	6	0	4	19	–	1	41
Nov. 28	11	49	9	51	–	1	58
Nov. 29	7	40	5	27	–	2	13

Thus, on November 2nd, the white spot followed the red by $3^h\ 49^m$, but, gradually drawing up to it, the interval decreased until November 19th, when the two objects mutually intersected the meridian at $9^h\ 23^m$. After this the white spot preceded by a distance rapidly accumulating, so that when I last observed both the spots, on November 29th, the interval separating them had become $2^h\ 13^m$; the daily excess of velocity of the white spot compared with the red had been 13½ minutes for the period included in the dates November 2–29, and slightly more than that (13 minutes) deduced from the whole series of observations from September 18th to December 3rd, referred to above.

It should be mentioned that in the sketches the objects are in each case represented as seen in an inverting telescope, so that the planet's east limb appears on the right-hand side, and the northern hemisphere is the lower hemisphere as depicted in the figures.

It is satisfactory to know that the singular white spot has been observed pretty frequently, and that it will be carefully watched as it successively becomes favourably presented on the disc of *Jupiter*. It is undoubtedly liable to great variations of brightness, and the light spots in its close neighbourhood have been noticed several times to alternately appear and disappear at remarkably short intervals. Indeed the effect produced has been something similar to that of dark clouds sweeping over brightly luminous regions; and the mere fact of recurrence of identical markings on the Jovian disc, leads to the inference that such phenomena are referable to atmospheric origin. It is impossible to conceive that such immense changes can occur on the real surface of the planet. They must be attributable to a rapidly variable envelope, influenced by swift currents and opposing forces, so that its density and thickness become thereby affected and the sunlight reflected in different degree.

Large openings may result, so that the lower strata become exposed, or even the actual surface of the planet itself rendered visible through the fissures. It would be strong evidence in support of the latter thesis should the fact of recurrent bright markings be fully established by further observations; for it will be impossible to explain them on other grounds than that they are physically connected with the planet. Temporary obscurations will be accounted for by atmospheric interferences.

The phenomena of the dark and red spots in regions of the north and south hemispheres may also possibly receive a similar explanation, though we require a mass of well-authenticated records before the solution of the question can be satisfactorily brought about. A series of reliable drawings representing the telescopic features of the planet at each ensuing opposition would, if extending over many years and executed by the same hand and instrument, be extremely valuable in such an investigation. A systematic scrutiny of the planet might be undertaken by a band of observers acting in unison, and the results accruing each year carefully registered for future comparison. Markings, if recurrent, would then be revealed in time, and their periods ascertained. It is true that drawings by different observers often show much dissimilarity; but this should not, in the case where a large number are available for comparison, have an unfavourable effect upon the discussion, because the different styles of depicting details must soon become apparent and might be allowed for throughout the series. Thus the sketches would become readily comparable, and admit of such mutual corroborative testimony as the subject allowed. Observers engaged in a work of this kind must, however, exercise extreme caution in representing the details just as they see them, and not allow their imaginations to influence them in the slightest degree. On bad nights, when definition is execrable and the interesting features of the planet blotted out, nothing should be attempted. It will be better to wait for more favourable conditions of atmosphere than to make an effort to reproduce what can, at the best, be very uncertainly seen, and what may prove an ultimate source of discordance and error.

The diminutive pictures of *Jupiter* which we are accustomed to see in popular works on Astronomy and in scientific serials, should give way to sketches of larger dimensions. It is impossible that the details can be suitably and adequately represented in drawings obviously too small for the purpose for which they are designed. It is true there is considerable difficulty in depicting this planet with all the details visible at a certain time; his swift axial rotation originates a rapid change in their apparent positions, and it is manifestly impossible to combine the observations of several nights because the objects have in the meantime undergone a great displacement in their relative places. Let any observer execute a careful sketch of the planet when the red spot is on the central meridian, and then, three or four nights later, make a similar drawing. He will, on comparing them, find they are utterly incompatible. The objects which in his first sketch were immediately adjacent to the red spot, are seen considerably in advance of it (towards the western limb), while others, which in his previous observations were between the centre and east limb are now lying directly under the red spot. Such facts have to be carefully considered by observers of Jovian phenomena, hence their sketches are necessarily hurried and often imperfect in details.

We have been particular in describing these observations of spots on *Jupiter*, because the phenomena so distinctly exhibited by them must obviously command the attention of every one interested in inquiries connected with the physical condition of the Jovian planet. The singular diversity of appearance and motions which have been pointed out, must be eagerly traced in their future sustenance and development; and it is of happy augury, as indicating the interest centred in the subject and the probability of its successful investigation, that so many observers are now devoting a share of their time to the work. The acquisition of numerous records that must accrue from many independent sources will possess considerable value, and be the means of eliminating such errors as are unavoidable in observations of meagre character.

Mr. Dennett at Southampton, Mr. Williams at Brighton, and the writer at Bristol, simultaneously pointed out the evidences of rapid proper motions in the dark spots recently observed ranged along a belt in the northern hemisphere of *Jupiter*. The white spot just south of the planet's equator was detected by the writer on September 18, and it came under general observation after November 17. Mr. H. Corder at Chelmsford has re-examined it on many occasions, and noted its transits across the central meridian of *Jupiter*. He had been previously led to infer the motion of the 'white ovals' on the equator from observations with a 4½-inch reflector in the autumn of 1879, and had given a summary of his observations in the *Observatory* for December of that year. From certain changes of position which he remarked on succeeding nights, he concluded that, relatively to the red spot, they completed a circuit of the planet in about forty days.

In conducting his recent observations, the writer has not paid special regard to the appearances of the satellites. Their shadows have been several times noted crossing the disc as black spots of very distinct aspect, and Satellite I. has been seen, both by Mr. Corder and the writer, projected on the disc as a dusky spot. These 'dark transits' of the first satellite are somewhat rare, though it would appear that during the present opposition they have quite lost their exceptional character.

The large extent of detail manifested on the surface of *Jupiter* has often impressed the writer with the necessity of a critical and searching review. There is a wide field here for patient labour and painstaking scrutiny. We have often heard of the vast amount of scenery on the lunar surface, and of the magnitude of the task involved in its complete delineation; and we have been told by those who have laboured in the field of meteoric astronomy, of the multitude and variety of the meteor streams which the Earth annually intersects. Indeed, each of us has learnt, in his own department, to realize something of the stupendous nature of the subject to which our individual energies have been applied, and to admit that we can never hope to attain more than a very partial knowledge at the best. In the scenery of *Jupiter* and its swiftly-varying aspects, we may find another large field for exploration, holding out as rich a prospect of successful results as that of any other branch of astronomical research.

Those who, during the last few months, have been engaged in examinations of *Jupiter* will frequently have turned their telescopes upon *Saturn*, situated not far to the eastward, and viewed his wonderful ringed sphere. It is true that this planet scarcely affords, from his greater distance, the same extent of detail as that perceptible upon the disc of *Jupiter;* but the appearance of the ring amply compensates for whatever is wanting in other respects: and there is this to be said, that *Saturn* is commonly much better defined in a telescope than *Jupiter*. The brightness and glare attending the latter planet brings about an indistinctness which only the best conditions of atmosphere can fully eliminate; while, in the case of *Saturn*, the moderation of lustre has the obvious effect of inducing the best performance of the telescope. This planet has lately been frequently subjected to careful inspection by the writer, and such features as could be discerned with certainty were noted down. The ring showed two divisions—one as a plain, black, curving streak, the other as an extremely faint line, not far from the outer extremity. The inner dusky (or crape) ring was also seen, and the exterior border of the outer bright ring seemed very dark, and where it was projected upon the planet, was visible as a dusky bar of shading, giving the impression that there is another dark ring lying closely outside the system of bright rings. Upon the planet himself a series of belts were always observed, though sometimes with greater distinctness than at others; but, compared with the belts on *Jupiter*, they were remarkably faint, wholly lacking that decided character and variegated aspect invariably shown by the latter phenomena. Near the south pole of *Saturn* there was a very dark cap, and separating this from the belts lying near the equator, there intervened a lighter zone. Bright patches were suspected on this, particularly where it came up to the planet's margin; and on November 17 a marking of this nature was certainly seen on the south-south-west limb, though it remained in view only for a short interval, and could not be reobserved on subsequent occasions. Some observers have referred to the figure of *Saturn* as sometimes assuming a singular form known as 'square-shouldered,' and the fact is supported on unequivocal testimony. The writer had not made many observations before this curious figure became distinctly apparent, causing an evident distortion of the globe, and a departure from the true spheroidal form. Attention was then more specially directed to the circumstances, and the explanation appeared to be that, while the bright belt above alluded to had the effect of apparently 'raising' the globe, the dark bands compressed it to such a degree as to bring about a very palpable deviation from the normal form. This is a fact which future observers should consider. In addition to the bright belt referred to, the system of *Saturn* exhibited two other markedly bright zones—one on the planet's equator, and the other lying immediately within the major division in the rings.

EXPLANATION OF PLATE I.

FIG. 1. *Jupiter*, his belts and great red spot. 1880, October 14th, $9^h\ 35^m$.

FIG. 2. *Jupiter* and his belts. 1880, October 24th, $11^h\ 15^m$.

FIG. 3. Section of the great equatorial belt, showing the white spot. 1880, November 28th, $9^h\ 51^m$.

FIG. 4. The white spot overtaking and passing the red spot, as observed on November 17th, 19th, 20th, and 21st. The apparent motion is from east to west, *i.e.* from right to left in the diagram.

FIG. 5. *Saturn* and his rings. 1880, November 28th, $8^h\ 30^m$.

THE ANATOMY OF THE STAG BEETLE.

BY A. HAMMOND, F.L.S.

[PLATE II.]

INSECTS are Articulated Animals, in which the integument plays the part of the internal skeleton of Vertebrates, forming surfaces for the attachment and play of muscles, as well as a covering and protection for the vital organs they enclose, for which purposes it is hardened by the deposition of a horny substance called chitine. In their simplest form, that of the maggot or caterpillar, insects much resemble worms, all the rings of the body being nearly similar to each other. In their perfect condition, however, the body exhibits three well-marked divisions, viz. the head, the thorax, and the abdomen, the two former of which bear articulated appendages. An alimentary canal traverses the body, and presents an œsophagus, crop, gizzard, ventriculus, or chyle stomach, and intestine. A chain of double nerve-ganglia runs, united by cords, along the ventral surface of the body, and is connected with the cerebral ganglia, or brain, by cords surrounding the œsophagus. Opposed to this is an elongated contractile organ, the dorsal vessel, the chief agent of the circulation. Respiration is effected by means of tracheæ, or breathing tubes, opening on the surfaces of the body by special apertures called spiracles.* The mouth-organs are modified limbs, and may be either manducatory or haustellate. They consist of a pair of mandibles, a pair of maxillæ carrying palpi, and the parts forming the labium, or lower lip, viz. the mentum, the ligula, and a pair of labial palpi; a horny plate called the labrum covers the mouth from above. Such is a rough outline of structures which it is intended to illustrate more fully in the insect which gives its title to this paper. Before, how-

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* The relative position of the alimentary, nervous, and respiratory systems, together with those of the different plates and appendages of the insect crust, are well shown in a figure from Packard. See Pl. II. fig. 9.

Fig. 3

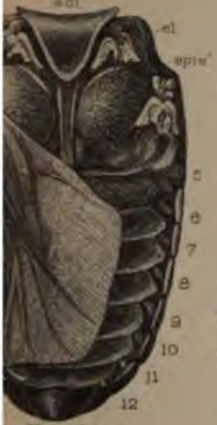

Fig. 2

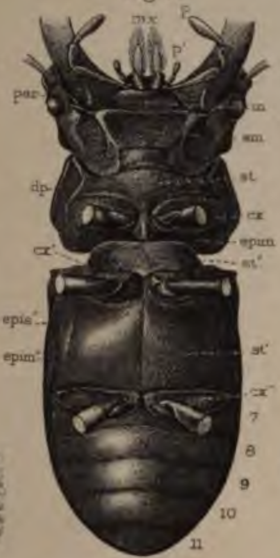

Fig. 1

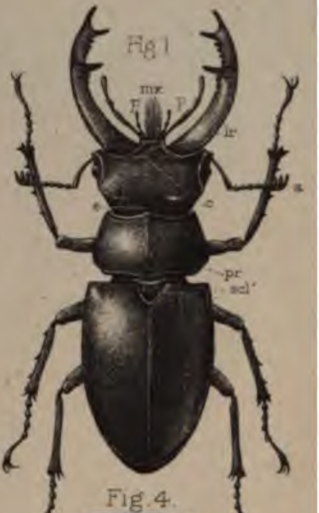

Fig. 5

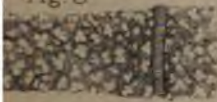

Fig. 4.

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Fig. 8.

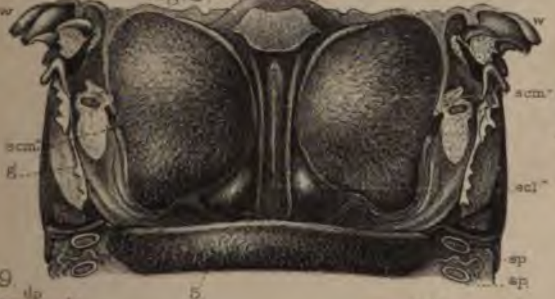


Fig. 6

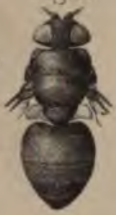


Fig. 9.

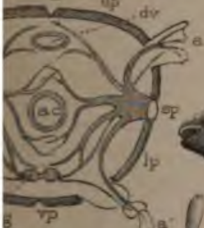


Fig. 10.

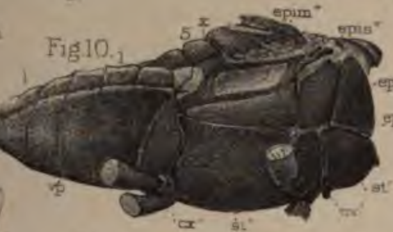


Fig. 11.

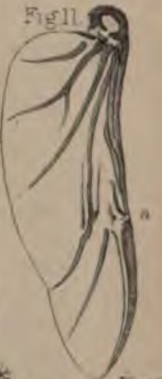


Fig. 13.

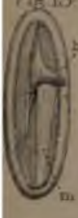


Fig. 14.

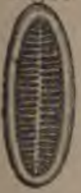


Fig. 15.

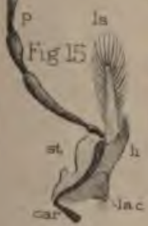


Fig. 17.

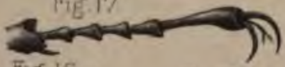


Fig. 16.

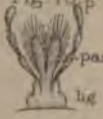


Fig. 18.

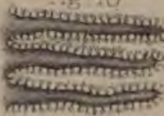
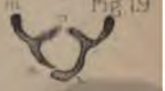


Fig. 19.



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ANATOMY OF THE STAG BEETLE.

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ever, entering in detail on our subject, it will be well to call to mind the principles which determine not only the rank of insects in the Articulate series, but that also of the different orders of insects among themselves; so shall we be able to view the structures presented to our notice, not as a piece of isolated animal mechanism, but as one holding its special place among others closely allied to it—an example not only of insect structure in general, but of coleopterous structure in particular. The Articulate type, under which Cuvier ranged all those animals whose bodies are composed of a number of successive rings or segments, includes the three great divisions of the Worms, Crustaceans, and Insects; and these take rank among themselves in proportion to the amount of specialization of function exhibited in their organization. This principle has been aptly termed by Milne Edwards as that of the physiological division of labour. The various actions and processes of life termed functions may be carried on, as in that simplest of all animals the Amœba, indifferently by any part of the body, or each function may have a special part of the body allotted to it; and in proportion as this is the case the various functions will be carried on with greater or less perfection. More especially is this seen with respect to the two great functions of animal life, viz. locomotion and sensation as opposed to the purely vegetative ones of nutrition and reproduction. It is the perfection of these functions which places so broad a stamp of superiority on the higher Articulate classes, viz. the Crustacea and Insects, as compared with their humbler brethren the Worms.

The result of this specialization of function, as exhibited in the body of an articulate animal, is chiefly its more and more perfect differentiation into the three regions of head, thorax, and abdomen; to the first belong the functions of sensation, to the second those of motion, and to the third the vegetative functions of nutrition and reproduction. The original division of the body into somewhat similar rings becomes subordinate to a new division into regions; and the more clearly this is observable, the higher rank will the animal exhibiting it take.

In intimate connexion with the alterations thus apparent in the external form, there is observable a concentration of the nervous system towards the head and thorax. In its simplest form which obtains in the Worms, this system consists of two longitudinal cords, each with a swelling (nerve-knot, or ganglion), corresponding to each segment. In the Diptera, as an example of one of the higher Insect orders, we find this chain of ganglia reduced to two—one in the head and one in the thorax,—the abdomen being supplied only with filaments from the latter. It is almost needless to point out how this concentration of the nervous system towards the head finds its highest expression in the complex brain of man and the Vertebrate animals.

The eight principal orders of six-footed insects have been arranged by Packard into the two following groups of Metabola and Heterometabola,* viz.

	Sub-orders, Packard.
Metabola. The body usually cylindrical; prothorax small; mouth parts more generally haustellate (formed for sucking); metamorphosis complete; pupa inactive; larva usually cylindrical, very unlike the adult.	Hymenoptera. Lepidoptera. Diptera.
Heterometabola; the body usually flattened; prothorax large and squarish; mouth parts usually adapted for biting; metamorphosis in a large number incomplete; pupa often inactive; larva flattened, often resembling the adult.	Coleoptera. Hemiptera. Orthoptera. Neuroptera. Thysanura.

In the Metabola, as the higher of these two groups, the differentiation of the thorax from the other parts of the body is more marked than in the other. The three segments of which it is composed, and which are known as the pro-, meso-, and meta-thorax, have coalesced together into a compact mass, separated by deep incisions from the head and abdomen.† The function of flight is chiefly concentrated in the mesothorax,‡ which segment is enormously enlarged at the expense of the other two. In the Heterometabola, on the contrary, the evidences of imperfect specialization are seen in the greater separation of the thoracic segments from each other, and their closer connexion with the abdomen.§ The power of flight is not so much confined to one segment, viz. the mesothorax, but is sometimes, as in the Coleoptera, resident in the metathorax, and sometimes, as in the Orthoptera and Neuroptera, the property of both; or, again, it may be absent altogether, as in the Thysanura.‖ In conformity with this, the nervous system in the Metabola, as also in the Coleoptera, as the highest order of Heterometabola, exhibits a greater amount of concentration than in the other orders; and the extent of the changes which they undergo in order to reach maturity is in a corresponding degree more marked.*

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* It should be observed that these two groups do not form a linear series, but rather two parallel ones. See Packard's *Guide to the Study of Insects*, p. 105.

† The regional division of the body is more marked than its division into segments.

‡ See figs. 6 and 7 in illustration.

§ In other words, segmental still prevail over regional distinctions.

‖ In the Hymenoptera and Lepidoptera there are two pairs of wings, but in the former the hind pair are not provided with muscles of flight, and in the Lepidoptera they are imperfectly so, the important longitudinal muscles being absent. I therefore regard them as subordinate to the front pair, and have described the function of flight as chiefly concentrated in the mesothorax.

In Pl. II. figs. 6 and 7, will be found drawings of the Blow-fly and Cockroach, as illustrations of the highest and lowest types of insect structure. In both will be clearly seen the characteristics just alluded to, and in the latter especially the similarity of the thoracic segments to each other and to those of the abdomen should be noted as evidences of a low grade of development. The place which the Coleoptera occupy in the scale will be rendered more clear when we describe the thorax of the Stag Beetle.

Commencing our description with the mouth-organs, we observe that the great horny mandibles, which so conspicuously adorn the head of the insect, are the exclusive property of the male sex, those of the female being small in comparison. They are situated immediately beneath the clypeus and labrum, to be presently mentioned, and are united to the upper and under surface of the head by a hinge-like joint, so as to work backwards and forwards in a horizontal plane. They are capable of biting with very great force. Notwithstanding the heavy appearance they give to the head of the insect, they are lighter than their bulk would indicate, being quite hollow, and the cavities occupied only by a cellular mesh containing air, probably a modification of the tracheal vessels distributed to this part. A strong, horny plate is seen between the mandibles on the upper surface, bent downwards, and constituting the labrum or upper lip. Pl. II. fig. 1, *lr*. This in most insects is articulated to the portion of the head immediately behind it, but in the Stag Beetle the two parts are immovably soldered together. Immediately beneath the labrum and mandibles are found the maxillæ, or lesser jaws, Pl. II. fig. 15, with which insects are always provided. They are partially concealed by the mentum, beyond which they project as two fringed lobes; they carry a pair of four-jointed palpi. Their motion, like that of the mandibles, is in a horizontal plane. In many beetles the office of the maxillæ appears to be the retention of the prey within the mouth, and assisting the action of the mandibles. As the Stag Beetle, however, is a vegetable feeder, subsisting upon the juices of trees which it has wounded with its mandibles, these organs are adapted to lap up the juices thus obtained.

Beneath these, and closing the mouth from below, are found the parts composing the labium, or lower lip. They consist of a broad, horny plate, the mentum, Pl. II. fig. 2, *m*, immediately within the anterior margin of which is a minute organ divided at its anterior extremity into two lobes, fringed with hairs, Pl. II. fig. 16, very similar to, though much smaller than, the fringed lobes of the maxillæ. These are the paraglossæ. They are regarded by some authors as a second pair of maxillæ; and, like them, they bear at their base a pair of minute three-jointed palpi.

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* It has been observed that as a rule the degree of perfection of an organism or an organ is the greater the more numerous the grades of development are which it must traverse to attain its full perfection.

The upper surface of the head is formed by a large rectangular piece, the fore part of which is called the clypeus, Pl. II. fig. 1*c*, somewhat produced at its anterior angles, where are situate the antennæ, consisting of ten joints, the basal one being very long, and the remainder attached thereto at an angle, thus giving an elbowed character to these organs, distinctive of the family Lucanidæ, to which the insect belongs. Of the remaining joints, the five terminal ones are formed into a pectinated club, somewhat resembling those of the Cockchafer, but not nearly so distinctly lamellated. The function of the antennæ is the subject of considerable diversity of opinion amongst naturalists, some believing them to be organs of hearing, some of smell, and others again of a sense unknown to us. A large and conspicuous nerve enters the base of these organs. Embryological considerations have led to the conclusion that the four paired organs, viz. the antennæ, the mandibles, the maxillæ, and the paraglossæ, are the limbs of so many segments of which the head is composed. The eyes are of the usual compound type; they are small in comparison with the size of the insect, probably for the reason that its vegetable-feeding habits do not require its vision to be so keen or so widely extended in range as in carnivorous species. A small process of integument called the canthus extends partly across the eye from its anterior border. This process is extended nearly or even quite across the eye in some of the burrowing Beetles, as in the common Dung Beetle (Geotrupes). The structure of the compound eyes of insects has been so often described that it does not seem to require special comment here. The multiplication of similar parts in the eye of the insect, as compared with the single and highly-finished organ of the Vertebrates, may be taken as an evidence of inferiority of organization. Behind the clypeus, and extending forward laterally as far as the eye, is a piece called the epicranium, Pl. II. fig. 1, *e*; and on the under surface of the head behind the mentum there are two other portions of the integument, respectively termed the submentum, Pl. II. fig. 2, *sm*, and the gula; but the boundaries of these parts, though clear enough in some insects, are rather difficult to determine in the Stag Beetle. The hinder surface of the head, where it adjoins the prothorax, is perforated by a large orifice, allowing passage for the œsophagus, nervous cord, &c.; and the portion of integument immediately surrounding this orifice is termed the occiput.

The complexity of structure in the head of the insect renders it futile to attempt to discriminate certainly the several segments of which it is composed from a study of its own structure; the only light that can be thrown upon it must be derived from an examination of the insect while yet in the egg. It is otherwise, however, with the succeeding portion of the body, the thorax, where, as has been already stated, the segmental division is much more apparent than in the Metabola of Packard, but the regional distinction less so. Hence results the possibility of mistaking at a first glance the large square piece which follows the head for the equivalent of the whole of the thorax, as we see it in the Bee or the Fly, the truth being that this is only the first of the three rings of which the thorax is composed, namely, the prothorax, as is immediately evident by the consideration that it carries only the anterior legs. Hence, also, arises the more intimate union and continuity of the metathorax with the abdominal segments, of which we shall have occasion to speak. The thorax is usually said to consist of three segments of the insect, viz. the second, third, and fourth segments, reckoning the head as one; but this is not strictly accurate, as the fifth segment, in a partially atrophied condition, is very frequently, as here, intimately united with it, and in the Hymenoptera is included in front of the thoracico-*abdominal incisure, as we shall presently explain. Here, also, is seen the most typical form of the insect segment, equally removed from the simplicity of the abdominal and the high complexity of the cephalic rings. Each consists primarily of four pieces—a dorsal, a ventral, and two lateral plates, as seen in the ideal section, Pl. II. fig. 9. The ventral plate is frequently called the sternum. Between the dorsal and lateral plates are placed the insertions of the wings, and those of the legs are found between the lateral and ventral plates. It is, however, by no means easy to follow out this ideal. The dorsal plate of the prothorax is very marked, being the large square plate between the head and the elytra (Pl. II. fig. 1, *pr*); the ventral plate is also clearly marked, see Pl. II. fig. 2, *st*; it is the large piece extending in front of and between the coxæ (*cx*). The lateral plates of this segment are not easy to trace. The French naturalist, Audouin, distinguished two parts in them, and illustrated them by dissections of the Great Water Beetle, *Dyticus circumflexus*. They are an anterior portion, the episternum, and a posterior portion, the epimeron. The former portion it is difficult to recognise at all in the Stag Beetle; and the latter is the narrow piece, which, in Pl. II. fig. 2, *epim*, is seen extending behind the coxa. On careful

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* See note to p. 21.

dissection, however, this piece can scarcely be regarded as a plate forming a portion of the crust of the segment, so much as a process of the same, bent down behind the coxa, to assist in forming the acetabulum, or place of lodgment for the latter, and anchylosed with the posterior extremity of the ventral plate between the legs.

It will be impossible, within the limits of this paper, to fully illustrate all the parts of which the thorax is composed. The two following segments are covered by the elytra and wings, which must be removed in order to reveal them. Having done this, we may find some difficulty at first in separating the mesothorax from the segment which follows, so firmly are they united to give solidity and strength to the body of the insect. By carefully bearing in mind, however, that this segment bears the elytra and intermediate legs, the separation can be effected; and it will then be found that it is perfectly distinct. Its most prominent feature on the dorsal surface is the small triangular plate, which is just visible between the elytra before these are removed, and is termed the scutellum (figs. 1 and 3, *scl.*) We cannot dwell upon this segment further than to observe that, in consequence of the great development of the prothorax in front, and of the metathorax behind, it is, so to speak, almost crushed out between them, in conformity with a general law of animal organization, which requires that the excessive enlargement of any one part shall be accompanied by a corresponding diminution in the parts adjoining it. In the Metabola, as has already been noticed, precisely the opposite of this occurs, the mesothorax being predominant at the expense of the other segments. This segment, it should be noted, is composed of the same constituent plates as the preceding and following ones.

The metathorax is the most highly developed segment of the thorax in the Coleoptera; to it is assigned especially the function of flight, and the segment itself, and the great system of muscles contained within it, are both specially designed for this end. The dorsal plate is shown in Pl. II. fig. 8. And here we may take occasion to notice the subdivision of its surface into four transverse parts, which Audouin, to whom we owe so much, was the first to point out. He regarded them as evidences of the ultimate subdivision of the elemental insect-ring into so many subsegments. These parts are perhaps better seen in the mesothorax of the Metabola, but are capable of demonstration here. They received from Audouin the following names, viz. the præscutum, scutum, scutellum, and postscutellum. Of these the scutum is that broad portion to which the wings are attached; following this is the scutellum, the anterior limit of which is not very obvious in this segment. This portion, however, is very well marked in the mesothorax, and has been already noticed. The præscutum lies in front of the wings, and the post-scutellum, as its name indicates, follows the scutellum. The two last-named subdivisions are generally bent downwards, to form attachments for the great longitudinal muscles of flight. In the lateral plates, just below the insertion of the wings, we again distinguish the episternum and epimeron; but so altered are the relative position of these pieces by the great development of the sternum, that we can scarcely recognize them as anterior and posterior in their relative position, but rather as inferior and superior. They will be seen represented in Pl. II. fig. 10. The sternum, or ventral plate of this segment, is the largest piece in the insect, and is divided by a central suture (see Pl. II. figs. 2 and 10). Although its typical position is between the legs, and indeed actually is so in some insects, it will generally be found in front of, rather than between, the coxæ, as in the present instance; it is of great strength, and gives origin to the great volume of muscles which occupy the lateral portions of the segment. Together with the greatly developed posterior coxæ which lie behind it, it extends the ventral surface of the metathorax far beyond its dorsal limits, which are marked by the inwardly developed post-scutellum; and the consequence is noteworthy. The ventral plate of the succeeding or fifth segment of the insect has disappeared, only the dorsal plate remains (Pl. II. fig. 8) to occupy the vacancy caused by the deficient backward extension of the dorsal surface.* This plate in the Stag Beetle assumes the appearance of, and is continuous with, the succeeding dorsal plates of the abdomen; but except at its posterior margin, it is connected on all sides with the metathorax; so that from one point of view we may regard it as the commencement of the abdomen, and from another as the termination of the thorax; thus illustrating the lack of that sharp separation between thorax and abdomen, in other words, the deficiency of regional distinction as compared with the Metabola which has been already referred to, while the great differentiation in form, in size, and in function, between the two wing-bearing segments, ranks the Coleoptera at once above the other orders of the Heterometabola with which it is associated.

The abdomen is that portion of the body of the insect which most strikingly retains its original articulate form, fulfilling, as it does, the functions of nutrition and reproduction which are characteristic alike of the lowest as well of the highest types of the Articulata. Perhaps it will be better to regard with Newport the fifth segment just described as a piece by itself, the thoracico-abdominal segment; then the true segments of the

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* This plate, as stated on p. 19, is in the Hymenoptera included with the thorax in front of the thoracico-abdominal incisure.

abdomen will consist of the sixth and following ones. Of these, seven are visible on the dorsal surface, and two at least, if not three, are concerned in the formation of the reproductive organs, making fourteen or fifteen segments in the insect, counting the head as one. The dorsal and ventral plates are well developed, the lateral ones scarcely at all. In order to allow room for the respiratory movements, the dorsal plates are soft and yielding, sufficient protection being afforded to the upper surface by the strong covering of the elytra.

In our review of the thorax, in order to give a more connected view of the several plates composing the same, we have omitted the subject of the wings and legs; and these important organs must now claim some of our attention. In the Worms, whose habits of life require little facility for locomotion, every segment takes part in the act of progression, as is also the case with the larvæ of insects themselves, at least those which undergo a complete metamorphosis; but in the perfect insect, where much greater facility of motion is required, we find the locomotive appendages confined to the thorax, where they receive their highest degree of finish. In the Annelids each segment bears two pairs of lateral appendages, or rudimentary limbs, the superior being dorsal and the inferior ventral. The wings of insects would seem to represent the former, and the legs the latter. The prothorax of insects is not ordinarily provided with superior appendages, but traces of such a provision exist in the pupæ of the Diptera, where they are adapted as breathing organs, the anterior extremity of the great tracheal trunks being carried into them; they disappear, however, in the imago. The development of the wings may be most advantageously studied in the common Cockroach, where they are seen to be gradually differentiated from the lateral portions of the dorsal plates of the wing-bearing segments. They are in principle sac-like processes of the integument, into which pass branches of the tracheal system. They thus always exhibit a double integument. The nervures are folds of the double integument, forming tubes along which the tracheæ run. The elytra, beside their modification of form, differ from the wings chiefly in the greater amount of chitinous deposit they contain, and their consequently increased solidity. This thickening, however, takes place in the outer integument only, the inner one lying next the body of the insect being soft and membranous. Between the two, in the Stag Beetle, there is a vesicular layer (Pl. II. fig. 5), formed by the ramifications of the tracheæ, ending in little bladders somewhat similar to those which occur in the body of the insect. This doubtless serves as a soft air-cushion to press upon the delicate wings beneath. The wings in this insect—as in most of the Coleoptera—are folded transversely beneath the elytra, the fold taking place at the point *a* in the drawing of the wing (Pl. II. fig. 11).

The legs exhibit the joints usually observable in insects, viz. the coxa, femur, tibia, and tarsus. The coxæ, or basal joints of the legs, are sunk in suitable cavities between the plates of the segments to which they belong,* so as to secure freedom from all possibility of dislocation, with a limited motion of revolution in an antero-posterior direction. The motion of the femora upon the coxæ, is in a direction at right angles to this; as is also that of the tibiæ upon the femora. The tarsal joints (Pl. II. fig. 17) are five in number, and are connected with each other by a ball and socket-joint, allowing of a limited motion in every direction. The last tarsal joint is considerably longer than the preceding, and is hollowed out at its extremity to receive the enlarged bases of the terminal claws with which it is armed, which lie side by side within it, and are free, like the joints of the tarsi themselves, to move, with certain restrictions, in every direction. Between the claws there is a small appendage, terminating in two minute pencils of hairs. The exquisite finish of the tarsi of this insect is well calculated to excite our admiration, though this may perhaps be said of every part of the organization of living beings in general.

The structure of the spiracles, perhaps, more properly belongs to a review of the respiratory system; a description of the external structure, however, would seem to be somewhat incomplete without them. They are the external orifices of the respiratory tubes, by means of which air is conveyed to every portion of the body of the insect. They occur in pairs, one on each side of the body, from the second to the twelfth segment inclusive, with the exception of the metathorax, which is unprovided with a spiracle. There are thus ten pairs of them, those of the thorax being larger than those of the abdomen. The former can only be observed by separating the segments between which they occur,—one pair between the pro- and mesothorax, and the other between the latter and the metathorax. They really belong to the posterior region of the segment in front of them. The abdominal series commence with a pair on the dorsal surface of the fifth or thoracico-abdominal segment, and are rendered visible by the removal of the elytra and wings. Each consists of a thickened oval chitinous ring (Pl. II. figs. 12, 13, 14, and 19), within which is a more delicate, horny margin, fringed with branching processes (fig. 18), serving as a kind of sieve to exclude foreign matter. Within this, there is a valvular aperture (figs. 12 and 13), one valve of which is provided with a handle-like process, into which is inserted a muscle arising from the margin of the spiracle at its superior extremity. The contraction of this muscle presses the valve which bears it upon the other, and thus closes the spiracle.

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* The intermediate coxæ are inserted between the sterna of the meso- and meta-thorax.

It was originally intended to pass in review the whole of the structure of this insect, internally as well as externally. The subject, however, has run out to a greater length than was anticipated, and we must refrain at present from pursuing it further.

The study of the development and anatomical structure of insects affords a vast extent of unbroken ground to many whose means of becoming acquainted with the broader aspects of the science of Entomology is, from various causes, limited to the observation of the familiar insects around them, and the extraordinary beauty and interest of the details which may thus be revealed may well prove the strongest incentive to master the drier technicalities of the subject which have occupied much of our attention in the preceding pages. Every part of insect structure will, on attentive examination, be found replete with what we may still delight to call Creative design. Does the House Fly or the Crane Fly sip its food by means which so long as they are unknown can excite but little interest? Dissect them, and the secret of the process is revealed in a pumping instrument, which the skill of the mechanician can scarcely approach. With a view to facilitate the acquirement by the reader of a personal acquaintance with some of these interesting subjects, the following observations are offered as the result of the author's experience. That patience and perseverance are necessary, it is scarcely needful to mention, as there is no royal road to knowledge of any kind. A certain amount of skill in drawing is highly desirable as a means of retaining observations made, which if committed to memory alone would certainly be lost. Insects for dissection should be collected, not as single specimens, but a dozen or two at a time, when opportunity offers; and if it is not convenient to make use of them at the time, they should be preserved in methylated spirit till wanted. By this means their internal parts are preserved, and the bleaching and hardening which they undergo is frequently an advantage, as it serves to render the nervous and muscular tissues more easily traced; but this should not supersede the dissection of fresh specimens. The internal organs in all cases, and sometimes the external parts, should be dissected under water. A compound microscope, such as may be purchased for 5*l.*, is desirable; and a dissecting microscope, similar to that recommended by the late Dr. Lawson, which, together with a suitable set of dissecting instruments, may be obtained from Collins for a trifle. The stage of this instrument is provided with a gutta-percha trough, to enable objects to be pinned thereto. A description of it may be found in *Science Gossip* for Sept. 1865. If artificial light be employed, a condenser should be provided to bring the rays of the lamp to a focus on the object. The internal soft parts will require to be teased out and floated away from their attachments with great care, and a jet of water directed upon the dissection occasionally from a small glass syringe will keep it clear from floating particles that would otherwise obscure the view. Clean sections made with a sharp strong knife through the thorax in different directions will show the disposition of the muscles. Very small insects, or parts of insects, must not be pinned, but dissected in a shallow receptacle, such as a watch-glass, and occasionally transferred for closer scrutiny to the stage of the compound microscope. The tools used, in addition to knives of different shapes, as sold by opticians, should comprise a pair of fine dissecting forceps, the points of which should accurately meet; and needles, straight and crooked, mounted in light wooden handles, may be easily made by the operator himself, and prove extremely serviceable. The following books of reference are recommended, viz. Burmeister's *Manual of Entomology*, Shuckard's Translation, 1836; Todd's *Cyclopædia of Anatomy*, Article 'Insecta,' by Newport; and Lowne's *Anatomy of the Blow Fly*.

EXPLANATION OF PLATE II.

FIG. 1. The Stag Beetle, natural size; mx, the maxillæ; p, maxillary palp; p′, labial palp; lr, labrum; c, clypeus; a, antenna; e, epicranium; pr, prothorax; scl′, scutellum of mesothorax.

FIG. 2. Ventral surface; mx, p, and p′, as before; m, mentum; par, paraglossæ; sm, submentum; dp, lateral margin of dorsal plate of prothorax; st, sternum; cx, coxa; epim, epimeron. In the meso- and metathorax, the corresponding parts are marked with a single or a double accent respectively, thus, epis″, the episternum of the metathorax. The following numerals indicate the ventral plates of the abdomen.

FIG. 3. Dorsal surface of mesothorax and following segments, the elytra and one wing being removed, the other one remaining to show its transversely folded condition; el, attachment of elytron; scl′, scutellum of mesothorax; epis′, episternum of ditto; scm″, scutum, and scl″, scutellum of metathorax. The numerals indicate the dorsal plates of the abdomen, each of which is seen to be furnished with a spiracle. The postscutellum is concealed.

FIG. 4. Transverse section of elytron, showing the thickened outer and the membranous inner integument, with the vesicular layer between.

FIG. 5. Portion of vesicular layer highly magnified.

Fig. 6. Dorsal surface of Blow-fly.

Fig. 7. Ditto of Cockroach. These two figures are introduced to illustrate the difference of structure between the Metabola and the Heterometabola, the prevalence of the regional distinction in the one, and of the segmentary division in the other. In the former, the whole of the central division of the body here visible consists of the mesothorax, with the exception of the anterior angles, which belong to the prothorax.

Fig. 8. The metathorax of the Stag Beetle, dorsal surface; prs″, the præscutum; w, the attachment of the wings; g, membranous continuation of ditto; sp, sp, spiracles of fifth and sixth segments; 5, dorsal plate of fifth or ventrally atrophied segment, the thoracico-abdominal segment of Newport. The remaining letters as before.

Fig. 9. Ideal diagram of an insect segment after Packard; dp, dorsal plate; lp, lp, lateral plates; vp, ventral plate; aa, dorsal appendages, the wings; áá, ventral appendages, the legs; ac, alimentary canal; ng, nervous ganglia; dv, dorsal vessel; tr, tracheæ; sp, spiracle.

Fig. 10. Lateral view of mesothorax and following segments of Stag Beetle; ll, lateral plates of abdomen; vp, ventral plates of ditto. The remaining letters as before.

Fig. 11. The wing unfolded; a, the point where the fold occurs.

Fig. 12. Abdominal spiracle, internal view, open; a, the aperture between the valves; h, the handle; m, its muscle.

Fig. 13. Ditto, closed.

Fig. 14. Ditto, external view.

Fig. 15. Maxilla; ls, the fringed superior lobe; p, the palp; st, stapes; li, inferior lobe; lac, lacinia; car, cardo.

Fig. 16. Labium; lig, ligula; par, paraglossæ; p′, palp.

Fig. 17. Tarsus of posterior leg.

Fig. 18. Branching processes of abdominal spiracle.

Fig. 19. Transverse section of ditto; m, the margin; p, processes; a, the aperture; h, the handle.

ON FOG.

By W. H. STONE, M.B.

IT is hardly a matter of surprise that there should occur periodical crises of public excitement on the subject of London fog. Indeed, it is strong evidence of the influence of familiarity in securing toleration that so little attention is usually paid to it. To foreigners the thing is mysterious, and almost awful. The plague of Egyptian darkness, chronicled in Holy Writ as a direct interposition of Divine vengeance with the object of terrifying a recreant tyrant into submission, is received with the hush of horror; and yet the inhabitants of England's metropolis calmly endure an exactly similar infliction to that recorded in the book of Exodus, not only without terror, but almost without remark. It is even similar in the fact of an extremely definite line of demarcation by which the darkness is occasionally bounded, and by the transparency of atmosphere, the persistence of daylight, which causes neighbouring spots to resemble the land of Goshen. 'No words,' says Mons. Taine in his *Notes sur l'Angleterre*, 'can describe the fog in winter. There are days when, while holding a man by the hand, you cannot see his face.' He quotes, moreover, from a writer whom he terms 'the greatest contemporary English painter,' a description so graphic and so scientifically accurate as to be worth reproducing:—

'It was a foggy day in London, and the fog was heavy and dark. Animate London, with smarting eyes and irritated lungs, was blinking, wheezing, and choking; inanimate London was a sooty spectre, divided in purpose between being visible and invisible, and so being wholly neither. Gaslights flared in the shops with a haggard and unblest air, as knowing themselves to be night-creatures that had no business abroad under the sun; while the sun itself, when it was for a few minutes dimly indicated through circling eddies of fog, showed as if it had gone out, and were collapsing flat and cold. Even in the surrounding country it was a foggy day, but there the fog was grey, whereas in London it was, at about the boundary line, dark yellow, and a little within it, brown, and then browner, until at the heart of the city—which they call St. Mary Axe—it was rusty black. From any point of the high ridge of land northward, it might have been discerned that the loftiest buildings made an occasional struggle to get their heads above the foggy sea, and especially that the great dome of St. Paul's seemed to die hard: but this was not perceivable in the streets at their feet, where the whole metropolis was a heap of vapour charged with muffled sound of wheels and enfolding a gigantic catarrh.'*

Scientific opinion, however, is far from unanimous as to the exact nature of the phenomenon. A recent correspondent of the *Times* newspaper, Dr. Alfred Carpenter, who led off the latest crisis alluded to above, boldly jumped at the conclusion that fog is simply powdered carbon diffused in the air, and issuing as such from non-smoke-consuming fire-places. This view is, however, demonstrably erroneous. It is easy to pass a large quantity of very foggy atmosphere through a small fluid or cotton-wool filter by means of what is termed by chemists an 'aspirator;' weighing the intercepting material before and after experiment. The increase of weight will be found infinitesimally small; the microscope, moreover, shows at those times hardly any increase, and in some cases a decrease in the quantity of finely divided carbon, which is always, to a certain extent, present in the air of large towns. It can be noticed by every person that the days when those literal *bêtes noires* of the housekeeper, 'the blacks,' fall on papers, books, and furniture, are not foggy, but the reverse, being usually dry, bright, and windy. And yet common sense and experience indicate some form of connexion between coal, smoke, and fog, of the 'London particular' variety. Its practical limitation to our coal-burning metropolis, and to some other large towns, such as York, where the same conditions prevail, is a strong argument in this direction. The writer's personal observation supplies another fact of the same bearing. When he was a student in Paris in the year 1856, wood was still the fuel burnt in the close stoves of that city; and the fogs which often delayed him on his journey to early morning visit at 7 a.m. in the old Hôtel Dieu, though dense, were almost white, and like country mist. Napoleon III. was, however, encouraging the use of coal, and hearths for burning it were rapidly replacing the old *poêle*, or the pair of dogs for supporting the burning log. Before his year of study ended, the character of the fog had materially changed; no doubt owing to the altered fuel, and several well-marked specimens of the London yellow variety came under his notice. Indeed, the surprised Parisians were energetically discussing the new invader as though it were Phylloxera, Aphis vastator, or the Colorado bug.

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* Dickens, *Our Mutual Friend*, iii. 1.

The part which suspended carbon actually plays in coal-smoke seems to have been first correctly pointed out by the late Mr. C. Wye Williams in his *Treatise on the Combustion of Coal, and the Prevention of Smoke.* A pretty experiment as to its great light-extinguishing power is quoted by the writer of an excellent article on this subject in a weekly contemporary, the *Engineer*, to which once for all the writer may acknowledge his indebtedness:—

'The weight of carbon in a cubic foot of black smoke is not equal to that of a single grain. Of the extraordinary light-absorbing property and colouring effect produced by the inappreciable myriads of atoms of this finely-divided carbon forming part of the cloud, some idea may be formed by artificially mixing some of it, when in the deposited form of soot, with water. For this purpose collect it on a metallic plate held over a candle or gas-jet, and touching the flame. Let a single grain weight of this soot be gradually and intimately mixed on a palette, as a painter would with a palette-knife—first with a few drops of gum-water, enlarging the quantity till it becomes a spoonful. On this mixture being poured into a glass globe containing a gallon of water, the whole mass, on being stirred, will become opaque, and of the colour of ink. Whatever, then, may be the quantity or number of its atoms, we see from the cloud of incombustible matter with which this carbon is so intimately associated as smoke, that even attempting its separation and collection independently of its combustion borders on absurdity.'

'But even if it were possible,' says the same authority, 'to totally prevent the evolution of carbon in a finely-divided state, we should have advanced but a short way on the path to be trodden. The carbon renders, it is true, a fog dirty and dark, but it is not the carbon which is the principal cause of the sore throats, bronchitis, and "colds in the head," which are beyond question brought on by the persistent inhalation of London fog. These are more than probably due to the presence in the fog of sulphurous acid gas, carbonic acid, and carbonic oxide, the two last fruitful causes of violent headache. No matter how perfect the combustion of the coal might be, these gases would be as plentiful as ever. To illustrate this truth, we may cite the Metropolitan Railway. The engines on it burn Welsh smokeless coal, and the conditions of combustion are made as perfect as science can make them; but the tunnels are filled with an atmosphere charged with carbonic acid, carbonic oxide, and sulphuric acid. The [illegible] that would be attained by smoke-preventing grates would be the prevention of the discharge of carbon in powder. In other respects the conditions would remain the same. The fog would be [illegible], and that is all.'

It is thus seen that other modes of accounting for fog must be sought for besides the crude and simple hypothesis of suspended carbon. This view was well developed in a lecture by [illegible] recently delivered at the meeting of the Balloon Society at Westminster Aquarium. He stated that from the surrounding of the sea the climate of England was more moist than many other climates, and had, therefore, a greater tendency to fogginess. In London fog resulted not alone from this cause and from the Thames, but from the exhalations of open spaces, where the rain had sunk into the soil. The canopy of compacted smoke from the [illegible] tons of coals annually used in the Metropolis prevented the evaporation of water, and caused the irritating effects of London fog. There were also the emanations from street-sweepings, manure-heaps, and the breath of millions of inhabitants, resulting, it was computed, in nineteen grains of sulphuric acid in every cubic yard of London air. Balloon experiments by Mr. Glaisher and others had proved that the fogs were not usually of high altitude, and that the sun was sometimes shining on high towers when all below was enveloped in mist. 75 per cent of light was thus intercepted, to the great detriment of animal and vegetable life, accounting, to some extent, for the comparative feebleness of London children. By way of reducing the deleterious influences, open spaces should be well under-drained, and, if practicable, more spaces or boulevards laid out to admit freer circulation of air. While smoke from factories could be checked, every private house was in winter a manufactory of smoke and soot. The use of smokeless coal and of smoke-consuming appliances would mitigate the evil: but it seemed to him that private houses might eventually be supplied with heat from some central source by means of electricity.

The best contribution, however, that we possess to the natural history of Fog is hardly so well known to the general public as it should be. This is mainly due to the fact that it is short and unpretending, and also to its being enshrined, and, to a certain degree, concealed, in the *Proceedings of the Royal Society*. On October 29, 1878, Prof. Frankland forwarded to his brother fellows a brief memoir occupying exactly three pages, but containing within this limited space very condensed and substantial matter. It is entitled, 'On Dry Fog,' and begins by stating the well-known fact that the foggy atmosphere, especially near large towns, is not always saturated with [illegible] For instance, on the 17th of that month, at 3.30 p.m., during a thick fog, the degree of humidity was only 80 per cent of saturation. The same phenomena had been observed by Mr. Glaisher in his balloon ascents, the hygrometer passing through cloud or fog often showing the air to possess considerable dryness. In an ascent from Wolverhampton in 1862, at a height of 9882 feet, in passing through a cloud so dense that the balloon could not be seen from the car, the dry-bulb thermometer read 37°·8 F., and the wet-bulb 30°·2, indicating a dew-point 17°·9 below the air temperature. On the 30th July of the same year, at an altitude of 6466 feet, while the balloon was passing between the Crystal Palace and Gravesend through 'a great mist,' the dew-point was 12°·7 F. below the temperature of the air. A table of sixteen such observations is given, in which, taking 100 as saturation, the real condition rises only once to 87, sinks as low as 46, and averages between 50 and 60, or rather more than half. It is thus evident, he observes, that air closely surrounding the spherules of water in a fog is sometimes far from containing its full proportion of watery vapour; 'although, as is well known to persons occupied with gas-analysis, when a perfectly dry gas is admitted into a moist eudiometer it very rapidly assumes the volume indicating saturation, notwithstanding that the proportion of water-surface to volume of gas is obviously far less than that afforded to the interstitial air of a fog.'

One experiment was made to test the latter fact, and it was found that air dried over calcic chloride became completely saturated in less time than $1^{m}\ 50^{s}$, when passed into a moist glass tube, ¾ inch in diameter. Dr. Frankland, in seeking for an explanation of the anomalous behaviour of the watery vapour in the two cases above, thought of some experiments made, many years ago, by Mr. Spence of Manchester, showing that the evaporation of saline solutions, kept just below their boiling point in open pans, can be almost entirely prevented by covering the liquid with a thin stratum of coal-tar. Mr. Spence in this way effected a considerable saving of fuel in that part of the process of manufacturing alum, in which burnt aluminous shale is digested for many hours with hot, diluted, sulphuric acid, by the lesser escape of steam from the surface of the hot liquid.

He saw in this simple process a condition of things under which the so-called 'Dry Fog' might be produced. 'From our manufactories and domestic fires,' he says, 'vast aggregate quantities of coal-tar and paraffin oil are daily distilled into the atmosphere, and condensing upon, or attaching themselves to, the watery spherules of fog or cloud, must of necessity coat the latter with an oily film, which would retard the evaporation of the water, and the consequent saturation of the interstitial air.'

Any person who has used the ordinary paraffin lamp oil, 'Rangoon oil,' or similar hydro-carbons as lubricators for machinery, must be well aware what a firm and coherent film they instantly form on the surface of water, and even on polished metal. In the latter case, their great preservative power against rust and tarnish is no doubt mainly due to this property—a property which has of late been further utilized in surgery for the protection from the air of raw wounded surfaces in man and animals.

To test the exact amount of the difference of evaporation, two platinum dishes containing water, and presenting equal surfaces of liquid, were placed side by side in a moderate draught of air, the water in one being coated with a very thin film of coal-tar. It was found that during twenty-four hours the evaporation was reduced by the film of coal-tar by 84·4 per cent in one case, and by 78·6 per cent in another. In order to imitate more nearly the action of actual smoke in foggy air, the smoke from burning coal was then blown on the surface of the water in one of the platinum dishes, and the evaporation was thus reduced by 77·3 per cent. In a large bell jar, the air of which was kept dry by a large surface of concentrated sulphuric acid, the effect of a film of coal-smoke varied, in six experiments, from 66·6 to 92·7 per cent.

All these concordant results are much too large to be accidental or erroneous, the only possible conclusion being that the real though vague connexion between fog and the imperfect combustion of bituminous coal, if not absolutely demonstrated, has thus, to a great extent, been explained and accounted for. Dr. Frankland remarks incidentally that the presence of liquid hydro-carbons in a diffused condition would also tend to explain the frequency, persistency, and irritating character of the fogs which afflict our large towns, inasmuch as some of the products of destructive distillation of coals are very irritating to the respiratory organs.

It has long been well known to practical men that we burn our ordinary domestic coal to a terrific loss. It is still more disheartening to think that we convert it into an interceptor of the light of heaven, and into a dangerous bronchial irritant. The worst of the outlook is that the evil seems to be spreading. 'The fogs of the earlier portion of the present year were not confined to London. They formed belts which reached from Paris in the south to Liverpool in the north. The whole English Channel was shrouded in them. River traffic was stopped repeatedly by them in Liverpool. But it is none the less true that what in the country was a clear and comparatively harmless white fog, was in London a dirty and noisome fog.' And hereout comes a social paradox of no small dimensions, with which Dr. Siemens, *more suo*, has not hesitated to grapple honestly.

It really seems as if we could burn our bituminous stores of fuel more economically, as we certainly can more pleasantly and healthily, by committing them to a preliminary sorting and separation into coke and gas. It will surprise no one at the present day to be told that slow, imperfect distillation in a small hearth is less thoroughgoing and perfect, and more liable to waste, than that of a gas retort. It is like bartering rough gold-dust against food and clothing, instead of having it first packed in neat circular blocks of equal value guaranteed by a government department. But, unfortunately, the middle-man, in the two cases, differs materially; and until the average Englishman possesses more power than he now has over the gigantic gas monopoly, he is not likely to reap the benefits of the discovery. He has not as yet gained by the improved methods introduced of late years for equalizing the supplies of fresh meat in different parts of the world; and if the butcher has been too strong for him in intercepting profits, how shall he struggle against the act-of-parliament protected gas companies?

As is usual in social questions of this order, the sufferer is himself most to blame. Coke is well known as a cheap fuel. It produces, when well managed, a brisk, cheerful, and singularly hot fire. But what householder of any experience has ever been able to secure its regular use in his domestic grate? Servants steadily, perseveringly, and heroically, refuse to touch it. If a store is kept in the cellar it is allowed to run out unnoticed, or, still worse, is buried beneath fresh and costly importations of new coal. Few householders, moreover, are aware that that singularly repulsive, dictatorial, and generally unmanageable functionary the sweep carries away as refuse in his bag what he gains far more by than he does by the money paid for the act of sweeping chimneys. Soot, which is only the difference between the waste coal and what has been converted into fog, is a valuable and most saleable commodity, which it is actually worth while to adulterate! It is imitated by dyed sawdust, and commands, even when thus sophisticated, an excellent price.

Mr. W. D. Scott Moncrieff, in a short paper headed 'Smokeless London,' which appeared recently in *Nature*, proposes a very practicable scheme in this direction. He takes advantage of the existing plant of the gas companies, who, instead of taking 10,000 cubic feet of gas per ton from the coal, are to take 3333 feet, and to pass three times the quantity of coal through the retorts. They will thus have double the quantity of by-products in the shape of tar and ammoniacal liquids, the community will have 24-candle instead of 16-candle gas, the fuel resulting from the process will light readily and will make a more cheerful fire, giving out 20 per cent more heat than common coal without any smoke. He works out the proposition in some valuable statistics too long for quotation, showing that the yearly value of London smoke, now lost, amounts to 2,125,000*l.*

Another important point to which attention has recently been drawn is the very partial and local character of a fog. Passengers by the Great Northern Railway, for instance, can easily observe its great prevalence in the valley below the ridge of clay hills termed the 'Hog's Back,' which form the northern wall of the basin of the Thames. On arriving at Finsbury Park, the line of demarcation is often distinct and wall-like. Here, no doubt, the geographical position, and the impervious nature of the strata, will account for the peculiarity. A similar case was noticed by Mr. White, the Secretary of the Royal Institute of Architects, on the 7th of December, in a letter addressed to the *Times*. He inquires whether the parks may not, in some degree, be responsible for the fogs which periodically obscure parts of London. The fog of December 2nd last is known to have prevailed principally in the northern, north-western, and western districts; at the termini of the North-Western and Midland Railways great inconvenience was felt. Now, on the afternoon of that day, at about half-past four, Mr. White passed through the Regent's Park, and there observed over a vast space, the circumference of which is three miles, a dense mass of bluish vapour rising, apparently, from the grass. In the midst of this vapour a feeling of damp cold was experienced, with a tendency to cough, while his beard and moustache were covered with globules of water. Objects at a few yards' distance could not be distinguished; both in the Euston Road and at Gloucester Gate the enclosure-walls of different houses streamed with moisture. At a later hour, at 11.30 p.m., he was in Portland Place, where foot-passengers clung to the area railing as the only means available for directing their steps. Arrived, however, at Oxford Circus, the fog was less dense; at the eastern end of Oxford Street comparatively little existed. He traversed the slums of Soho, Covent Garden, and the Strand, without any difficulty, and the City was free from fog. 'I beg,' he says, 'scientific men who are interested in this matter to visit the Regent's Park any day this winter between 4 and 5 p.m. I have been told that the drainage there is of an obsolete character, and from my experience of this and last year, when London has been visited with fog, the cloud has seemed to me to be thicker in Portland Place than in Oxford Street, or even in the Strand.'

The publication of the above letter gave rise to a lively correspondence, two independent correspondents confirming Mr. White's facts; and a third, Dr. G. V. Poore, adding the following comment:—

'If your correspondents will refer to Jordan's Geological

Map of London, published by Stanford, they will find that Regent's Park and Holland Park—two fog-haunted districts—are both upon the clay. The Holland Park district is indicated in this map by a tongue-shaped piece of clay wedged in between gravel to the east, and brick-earth to the west; and it is probably owing to this fact that fog is "more dense in the immediate neighbourhood of Holland Park than in the streets of either Kensington or Hammersmith," which are both upon the gravel.'

On the 10th of the same month an interesting letter appeared from Paris, strongly corroborative of the writer's views as given in a previous page:—

'The present agitation,' says Mr. Sandeman, 'concerning fogs which is engaging so much attention in London may now be studied here with much greater advantage. The fuel consumed has undergone a remarkable change within the last ten years, and each individual can appreciate the change which has taken place in the frequency and density of our fogs, entirely attributable to the enormous increase in the consumption of coal. Ten years ago it was about 150,000 tons per annum as compared with 700,000 last year. Coal is rapidly replacing wood, and must continue to do so, on account of the much greater and yearly increasing cost of the latter. Paris has to-day been visited by a fog which would not lose much by comparison with one of our own London ones; and the well-known electric lights of the Avenue de l'Opera were unable to penetrate it much better than their yellow gas *confrères* of the Rue de Rivoli. For Paris there is yet a chance, as all recognise the immense advantage of anthracite and other smokeless coals; and, fortunately, the present generation can remember when this state of things was wholly unknown. In London we have been brought up to look upon it as an inevitable accessory of the winter months, but here there is a much more favourable opportunity for experiment and proof.'

Mr. Edwin Chadwick, at a recent meeting of the Society of Arts, contributed an essential factor to the discussion by noticing the effect of drainage in relieving a district of fogs; instancing Richmond Park, which was once the site of heavy fogs and mists not contaminated by the 'blacks' of London, but which are now comparatively free from them. Mr. G. J. Symons, at the same meeting, made some good practical observations, agreeing that fogs are due to a wet soil, and that they had been exceptionally intense of late years, because the years had been beyond the average wet; but he denied that they were on the increase, or any worse than those of years ago. Low temperature with high barometric pressure of the nature of an anticyclone he held to be, with a cold soil, the meteorological con-

[illegible] preserved [illegible] before [illegible] would more [illegible] ammonia [illegible] for six [illegible]

[illegible] of fog which [illegible] hitherto neglected [illegible] power. This is [illegible] of carbon [illegible] experiment given [illegible] necessary to [illegible] steamer's [illegible] signally [illegible]

[illegible] quite separate [illegible] distant objects [illegible] distinctness, are [illegible] the light and not the definition, [illegible] Now it should be noted that exactly the same [illegible] with a snow-cloud. The blackness of an [illegible] phenomenon which [illegible] with that of fog. And yet we know that [illegible] is situated in an infinite number of [illegible] masses of frozen water, in themselves transparent and [illegible] It is obvious that the same process is in action as that which renders a mass of transparent glass, when powdered, absolutely opaque; namely, the breaking up of the light by internal reflections and refractions of heterogeneous character. It seems far from improbable that this explanation may bear being extended to the case of fog, especially if Dr. Frankland's hypothesis of its spheroidal cellular state be admitted. The yellowness may in such case be largely due to diffraction from bodies of very minute but similar size, bearing some simple ratio to the wave length of yellow or orange-coloured light. Secondly, considerable corroboration of such a view may be de- the fact mentioned by the Paris correspondent of the

Times, that the electric light hardly penetrated further than the ordinary gas flame: an observation which can be easily substantiated on any foggy night from the parapet of Westminster Bridge. The gas flame is notoriously rich in yellow vibrations; whereas those that give to the electric arc its dazzling and somewhat ghastly brilliancy belong to the violet, and even the ultra-violet end of the spectrum. Such vibrations would be entirely cancelled by an absorbent medium of monochromatic vapour, whose wave-length lay in the neighbourhood of the D. Sodium lines. It would be an interesting and complementary experiment to determine whether a strong Sodium flame would prove to be exceptionally transmissible through fog: certainly the red and flaring 'links,' made of rope-yarn, plentifully served with pitch, which used to be brought out on such occasions, and which were in the last century carried by footmen behind private carriages, seem to point in this direction.

The causes, then, of Fog, may be fairly divided into those which are climatic, and others which are due to the use of mineral coal. Besides these two, locality and geological structure must not be overlooked. It is not only unnecessary, but unscientific, to refer points needing investigation of this character to 'some magnetical changes,' the nature of which is not apparent. This absurd proposition was actually sustained by Dr. Carpenter at the Society of Arts, and fairly deserves the comment of a scientific contemporary, 'We fancy that Dr. Carpenter has written without taking time to think, for it is certain that his letter contains some fallacious reasoning based on a want of knowledge of the facts.'

Very different as specimens of patient induction, free from hasty jumping at irrelevant conclusions, are the views of Dr. Frankland given above: probably they approach more nearly to a scientific solution of the enigma than any others.

But when the question of practically remedying an acknowledged evil is raised, the matter becomes more complicated and difficult: indeed, different minds seem to have approached the topic by various avenues of thought. Captain Galton, in his lecture, lays especial stress on the climatic and geological element.

'The London basin,' he says, 'may be described generally as formed of clay, which retains the moisture from rainfall; deposits of gravel rest in many places in the clay. These deposits are not usually of great depth. The river Thames runs through the centre of London. The surface of the metropolitan area when built over, is generally well drained, and all moisture which falls is rapidly removed; but there are numerous spaces not built over, where the rain sinks into the soil, as, for instance, the parks, squares, gardens, &c., and there are also bodies of water in London which contribute moisture. These may be noticed as constituting a local cause of fog. Independently of the local cause of fog, which, no doubt, may always be mitigated to some degree, there remains the permanent cause, which arises from the geographical position of England—a comparatively small island surrounded by the sea—and that is a cause over which we can have no control.' Whereas another authority's confession of faith 'consists in stating that London fogs are due to London smoke—are, in fact, frequently made up of smoke, and nothing else; and that if we could get rid of smoke we should probably be rid of fogs at the same time.'

Probably the truth lies somewhere between these two extremes; the correlative remedies being better drainage, and more perfect and economical combustion of our bituminous fuel. The former reform must be left in great measure to public bodies—such as the Metropolitan Board of Works. The latter is to a great extent in our own hands, and will amply repay closer attention than it now obtains. The mere use of coke instead of coal for domestic fires, if sedulously and perseveringly insisted on in opposition to the prejudice and obstinacy of servants, will achieve much. In time Dr. Siemens's apparent paradox that it is better and more economical to divide our raw coal preliminarily into two manufactured products, gas and coke, before recombining them in a properly constructed hearth, may prove a truth of practical application, and may be made to save for use many costly by-products now lost and allowed to do injury. Captain Galton makes a good suggestion,—

'Open spaces should be created. Of course, if we could cut London in two from north to south by a broad open space, as it is cut in two from east to west by its river, it would do something to break up the cloud of smoke. In the year 1852 Sir Joseph Paxton proposed to carry a broad boulevard round London. It was a very feasible scheme in those days; it is a pity it was not carried into effect. Open spaces carefully underdrained, and so situated as to favour the circulation of air through the centre of London, would form a most important feature in promoting the health of London, if such things were possible.'

It remains to be seen how far his proposed object will be furthered by the great arterial streets from Holborn to the Strand now in contemplation.

As regards the decarbonization of domestic smoke the question is more arduous. In our household fire-places the temperature is never very intense, the supply of air ample; the smoke is evolved only because the temperature is not high enough to cause ignition and combustion of the gas and suspended carbon. It is not practicable in any open fire to get a sufficiently high temperature to secure the required end. Automatic or closed stoves of all kinds seem out of the question, and, indeed, make as much smoke as an open grate; only it is not seen till it escapes at the chimney-top.

Another, and far more hopeful scheme, is advocated by a writer in the *Engineer*, a class paper already referred to, and which is specially qualified to speak on such a subject. It has the advantage that it 'would leave us our open fires and our coal just as they are. It consists in depriving the smoke of its suspended carbon. To a large extent this is done for us already by our chimneys. The sweep every year takes away enough soot to render London fogs—were it found in them—ten times worse than they are. There is every reason to believe that the partial or total cleaning of household smoke is not at all beyond the reach of the inventor who will approach the subject with an intelligent perception of facts. Why is it that much of the soot is now deposited in our chimneys? The answer is that the particles come in contact with the sides, lose their velocity, and fall, or adhere to the bricks. It is well known that wherever an eddy can be formed in a chimney there will soot be deposited in quantity. Soot is delivered from the top of a chimney solely because the particles are very small, so small that their superficies is enormous as compared with their solidity. Consequently they are when set afloat in a current of air easily borne up and carried to the top of the chimney. Once there the current is gone, and they fall by their own gravity as a shower of "blacks." Now, if the velocity is once taken out of them and they are not permitted to be caught up by a current again, we are done with them as far as smoke is concerned. To get rid of them we must do just what is done in getting moisture out of steam—permit the current to strike a series of flat surfaces from which it is deflected. These surfaces, so to speak, "knock" the water out of steam. The principle has been very elegantly employed in a gas purifier which we illustrated in our pages not long since. The object in view is to get rid of carbon in suspension in the gas.' That such a plan could be rendered efficient 'is certain, but that trouble and expense would be incurred must not be denied. Its great claim to popular support would consist in the fact that its adoption would interfere with no popular prejudice in favour of open fires and their existing management.'

SOME FACTS ABOUT FISHES.

BY THE EDITOR.

RECENT researches, and especially those explorations of the deep sea which have been systematically carried on of late years, have brought to light numerous interesting facts in relation to fishes. Some phenomena previously altogether unsuspected have come to our knowledge, whilst others have been shown to be of far more general occurrence than has hitherto been supposed. In the present article we propose to call attention to one or two prominent points brought out by late investigations.

Anything like a true metamorphosis is of very rare occurrence among fishes. Indeed, the only change which can, to a certain extent, be compared with the metamorphosis of the Batrachia, is presented by the Lampreys; and even in them the change from what we must call the larval condition to that of the adult, is by no means so great as that from the tadpole to the perfect frog or newt. The lampreys, as most people are aware, are eel-shaped, scaleless fishes of very low organization, destitute of paired fins, having on the head a pair of eyes and a single nasal aperture, and on each side behind the head seven apertures belonging to an equal number of branchial sacs. The mouth, which is situated quite at the anterior end of the animal, is formed by a shallow, circular cavity, at the bottom of which the actual opening is situated, having a peculiar horny tooth above and another below it, and a similar armature upon the tongue, which occupies the aperture. Besides these the inner surface of the funnel-shaped cavity has numerous conical teeth, which are really the horny coverings of so many small papillæ; and these are of use to the animals when attaching themselves by suction to other objects. In fact, they adhere by their mouths to the stones at the bottom of the streams which they frequent, and thus, without much bodily exertion, they resist the action of the current (from this habit the generic name of the Lampreys, *Petromyzon*, or Stone-sucker, is derived); but they also avail themselves of their power of adhesion for a less peaceful purpose, attaching themselves in this way to the bodies of other fishes, whose flesh they then consume by means of their larger teeth attached to the jaws and tongue. In this perfect condition, so far as their habits are known, the Lampreys must be regarded as decidedly predatory fishes.

The streams inhabited by Lampreys are found to harbour another fish of very similar form, which, from its habit of concealing itself in the sand of the bottom, has long been known as the Sand-pride (Pride being a local name for the small river lamprey), and, under the generic name of *Ammocœtes*, regarded as a distinct form of the Lamprey family. In general form it is like a lamprey; it is equally destitute of paired fins, and has also seven branchial apertures on each side near the head; but the eyes are exceedingly small, deeply seated, and concealed beneath the skin, and the mouth, instead of constituting a circular suctorial organ, is a horseshoe-shaped cavity, surrounded in front by a sort of membrane, and furnished internally with numerous slender papillæ, but destitute of horny teeth, and quite unfitted for attaching itself by suction to any object. The food of the Sand-pride appears to consist of minute aquatic organisms, obtained from the sand or mud in which it lives.

The researches of Dr. August Müller first revealed the existence of a more intimate relation between the *Ammocœtes* and the Lampreys, than that implied in their belonging to the same family, and to nearly allied genera. By observing the small river lampreys in the act of spawning and securing the spawn, that naturalist was enabled to watch the development of the embryos in the eggs, and was rather surprised to find that the young fish produced, after growing for a short time, presented all the characters of the Sand-pride or *Ammocœtes*. Subsequently he observed the transformation of the *Ammocœtes* into the Lampreys; but the most remarkable point about this metamorphosis is that it is comparatively sudden: it is not until the fourth year of its existence that the fish passes from the larval to the adult condition, and the metamorphosis is effected by a series of changes taking place rather rapidly, thus reminding us somewhat of what occurs in insects, rather than of the gradual modification of the Batrachian larvæ. From the occurrence of *Ammocœtes* in the fresh waters of various parts of the world where river lampreys have been met with, it would appear that this metamorphosis may be regarded as general throughout the Lamprey family, although as yet nothing seems to be known of the transformations (if any) undergone by the Marine Lampreys.

A minor change, also partially analogous to what occurs in the Batrachia, is to be found in the presence of external branchial organs in the embryos of Sharks and Rays, and in the young of certain Ganoid fishes, especially of *Protopterus*, the African Mudfish. These branchiæ, as in the Tadpoles of frogs and newts, disappear in the further development of the fishes, the last named of which, in many respects, seems to lead from the true fishes towards the Batrachians.

But although we cannot say that an actual metamorphosis occurs in any other fishes, it has long been known that changes do take place in some of them, and that in many cases the young fishes differ very considerably from the adults. It is only of late years, however, that any conception has been arrived at of the extent to which these changes may attain; and it is mainly to Dr. Günther, the keeper of the Zoological Department in the British Museum, and to Dr. Lütken of Copenhagen, that we are indebted for the knowledge of the changes of form occurring in fishes that we now possess; the former gentleman having described numerous instances in various memoirs published during the last twelve years; and the latter being the author of several scattered papers on the subject, and quite recently of a valuable memoir on the changes observable in fishes of the Atlantic,* in which he has summed up and illustrated many of his own and Dr. Günther's results. Dr. Lütken proposes to denominate these changes of form 'hemimetamorphoses.' Dr. Günther has also devoted a chapter in his recently published and admirable *Introduction to the Study of Fishes* to a general consideration of these phenomena.

Without figures, both of the different young forms and of the adult fishes, it is of course, in many cases, impossible to convey an intelligible idea of the changes which have been brought to light by the investigations above referred to, but we will endeavour to describe two or three of them so as to enable the reader to see the bearing and importance of such results as have been, or may be, obtained in this field of research.

The occurrence of important changes in the so-called 'Flat fishes' (*Pleuronectoidei*) has long been known, but as they are very curious we may devote a few words to them here. These fishes, of which the turbot, the plaice, and the sole, are well-known examples, always have the body broad and much compressed from side to side; they live upon the bottom, where they are in the habit of lying quietly, and the two sides of the body are differently coloured,—that which is kept habitually downwards and applied to the ground in repose being of a white or pale colour, while the opposite surface, which is turned upwards, is of a darker tint, and apparently coloured to secure concealment by its resemblance to the surrounding sand, &c. In many fishes—perhaps in most—we may remark a similar difference between the coloration of the upper and lower surfaces; but in these it is the back and the belly that afford the contrast, whereas in the Flat-fishes the two sides of the body are thus differently coloured, and the animals swim and lie upon the bottom in a position at right angles to that taken by all other fishes. The long fins which fringe the two edges of the body of a sole or turbot, are really the dorsal and anal fins. In order to fit the Pleuronectid fishes for this peculiar condition of life the two eyes are both placed upon the same side of the head, the coloured or upper side, where alone under ordinary circumstances they could be of any use to the animal; and this is associated with a curious contortion of the bones of the skull, and a twisting of the mouth of the fish, such as often gives it a very singular aspect. When very young, however, the Flat-fishes do not present any such peculiarities: they are perfectly symmetrical, transparent little creatures, having one eye on each side of the head like other fishes, and they swim in a vertical position, like any other deep-bodied member of their class. The change from the symmetrical condition of the head in the young fish to the distorted form which it presents in the adult, takes place at a very early period, but how this wonderful conversion is effected does not seem as yet to be quite satisfactorily made out.

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* 'Spolia Atlantica,' in *Kongl. Danske Vidensk. Selskabs Skrifter*, 5th series. 1880. This Memoir is in Danish, but the author has appended to it a *résumé* in French, a translation of which will appear in the *Annals and Magazine of Natural History*.

'Whilst some naturalists,' says Dr. Günther, 'believe that the eye turning round its axis pushes its way through the yielding bones from the blind to the upper side, others hold that, as soon as the body of the fish commences to rest on one side only, the eye of that side, in its tendency to turn towards the light, carries the surrounding parts of the head with it; in fact, the whole of the fore-part of the head is twisted towards the coloured side, which is a process of but little difficulty as long as the framework of the head is still cartilaginous.' *

A priori, the second explanation seems to be by far the more probable one, and we must confess that we thought it had been finally established by Dr. Traquair in his valuable memoir published by the Linnean Society.†

This change in the Pleuronectidæ, from its nature, the importance of the organs affected by it, and its singularly abnormal results, may perhaps be regarded as an extreme instance of 'hemimetamorphosis;' but from the very early period in the life of the fish at which it occurs, and its uniformity throughout a considerable group of fishes, to which it is limited, it does not affect ichthyological researches in the same way as certain less profound alterations occurring in other types of fishes. It is for the knowledge of these that we are more especially indebted to the investigations of Dr. Günther and Dr. Lütken. One of the commonest peculiarities of young fishes is the presence on the margins of the opercular bones, and especially of the præoperculum, of numerous denticulations, which are gradually effaced by the growth of the bone, and are altogether wanting in the adult. In other cases certain bones belonging or in immediate contiguity to the head, such as the præoperculum, supra-scapula, and humerus, become enormously developed, forming large plates, which regularly cuirass the front half of the fish or the greater part of it, and from these and other bones of the head formidable spines or other processes may be developed. Dr. Günther figures a young *Pomacanthus*, in which the supra-scapular and præopercular plates are thus produced into immense spines, the former concealing the fore-part of the dorsal fin, and the latter entirely hiding the ventrals. In this well-armed infant the frontal bone is produced over each eye into a long, pointed, lancet-shaped spine; and altogether, small as it is, this young fish would probably be a very uncomfortable morsel to swallow. In another similar form the frontal spines, instead of being straight and pointed, represent long, curved horns. These cuirassed young fish were formed into a distinct genus, named *Tholichthys* (in allusion probably to the dome-like bony front of the species first described); they are now recognized as constituting a stage in the development of certain fishes belonging especially to the Chætodons and the allied groups Carangidæ and Cyttidæ.

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* *Introduction to the Study of Fishes*, p. 553.

† *Linnean Transactions*, vol. xxv. p. 263.

In many different forms strong spines are developed from various bones of the head and operculum, without any special dilatation of these into bony plates, as in the *Tholichthys;* and, no doubt, in these cases also the protection of the young animals from the assaults of their enemies, is the office of these comparatively formidable armatures. Such opercular and cephalic spines are characteristic of the young Swordfishes, in which they spring from the parietal and præoperculum, and attain formidable dimensions; and in these and other cases where the spines are greatly developed, they must, doubtless, be partially got rid of by absorption, or thrown off as the fish advances towards maturity. The development of the Swordfishes is particularly instructive, and we shall therefore endeavour to describe the stages through which they pass.

The Swordfishes, the largest forms of the ordinary bony fishes (*Teleostei*), sometimes attaining a length of twelve or fifteen feet, constitute a family not far removed from the

Scombridæ, represented by the Mackerels and Tunnies, of which the latter also attain a large size. They have a robust, spindle-shaped body, tapering gradually towards the tail, which is an exceedingly powerful organ, enabling these fish to travel through the water with great rapidity. The two principal genera are *Xiphias* and *Histiophorus*; the former, characterized, *inter alia*, by the total absence of the ventral fins, including the Swordfish so common in the Mediterranean (*Xiphias gladius*), which also occurs in more northern seas, and is occasionally taken off the British coasts; the latter, in which the ventrals are represented by a pair of long, pointed, styliform appendages, being confined to the tropical and subtropical parts of the two great oceans. In both genera nearly the whole length of the back is occupied by a very high dorsal fin (especially elevated in *Histiophorus*), but which is usually more or less worn away in old specimens; and in both the upper jaw terminates in a long bony spike, the so-called sword, formed by the maxillaries, præmaxillaries, and vomer, and projecting far beyond the anterior extremity of the lower jaw. This sword, which in large specimens may attain a length of two or three feet, with a diameter of two or three inches towards its base, constitutes a most formidable weapon, with which the swordfish is said to attack whales and wound them severely, for what purpose is not known. Sometimes, with a gallantry like that exhibited by Don Quixote in his celebrated attack on the windmills, and probably urged by a somewhat similar mistaken impulse, the swordfish will assault a passing ship or boat, and the power of the fish in the water is so enormous that it will drive its weapon a long way through even a thick plank. Such exploits, however, are performed at the cost of the weapon, for the unfortunate swordfish, being unable to withdraw its beak, its struggles to get free, aided probably by the motion of the vessel through the water, generally break the bone short off. The jaws are toothless.

The characters presented by the young swordfish for some time after their exclusion from the egg are exceedingly different from those above described. In general, the changes undergone appear to be very similar in the two principal genera already mentioned; but as the series of forms described is more complete in the case of *Histiophorus*, we may take this as our example.

The earliest phase known in the development of *Histiophorus* is described and figured by Dr. Lütken, and is certainly as unlike its parents as any young creature would wish to be. The specimen measured only about one-fifth of an inch in length, and was probably not long out of the egg when it was captured, and consigned to the spirit-bottle. The body terminates in front in a head much larger in proportion than in the adult swordfishes, and tapers off behind the head to a comparatively slender tail, marked on each side with a small ridge (a character which also occurs in the adults), and furnished with a very small, entire fin. On each side of the head is a large, round eye, and in front of this the forehead of the little fish descends rapidly to the base of a slightly projecting beak, which, however, is not so long as the diameter of the eye. The beak includes both jaws, and the upper jaw is very little longer than the lower one; the jaws open quite back under the eyes, and both of them are armed with comparatively strong teeth, those at the apex of the jaws being stronger than the rest, and curved. The spine springing from the præoperculum is much longer than the short round pectoral fin, and the edges of this and of the parietal spine are finely serrated. Small spines occur both above and below the præopercular spine, and over each eye there is a small supra-orbital spine, which, however, disappears very early. Besides the pectoral fins, which show indications of rays, and the caudal already mentioned, there are rudimentary dorsal and anal fins, consisting simply of membrane, with no trace of rays. It will be easily seen that such a little creature as this has scarcely any resemblance to the adult swordfish; and, indeed, Dr. Lütken says that but for the previous knowledge of the developmental stages of these fishes, his youngest forms would rather have been referred to some fish allied to the Flying Gurnards (*Dactylopterus*). This youngest stage is made known by one of a series of small fishes advancing from rather more than one-fifth of an inch to rather less than half an inch long; and the whole of these, Dr. Lütken says, differ very little from each other, the principal difference apparently being that the younger the fish, the shorter and broader is its little beak. Nevertheless, the largest of Dr. Lütken's earliest series exceeds in length the specimen on which Dr. Günther's first stage was founded, as this was only 9 millimetres (rather more than one-third of an inch) long, although it already shows signs of a more advanced development. The general form of the fish more nearly resembles that of the adult, although the head and eyes are still of rather disproportionate size; the forehead still falls abruptly in front of the eye; but the beak is comparatively longer, although the jaws are still nearly of equal length, and armed throughout with teeth. The spine above the eye, and the small spines on each side of the præopercular spine have apparently vanished; the præopercular spine itself is comparatively longer than in Dr. Lütken's earliest form; the dorsal and anal fins form low but distinct fringes, quite separate from the caudal, which is already rayed and forked; and beneath the pectorals small rudiments of the ventral fins have made their appearance. In a second stage, a fish, but little more than half an inch in length, is described and figured by Dr. Günther as having the head more nearly in proportion to the body, although the eye is still large and the forehead steep, but less so than in that just noticed; the beak is still formed of the two jaws, fully armed with teeth, but the upper jaw slightly exceeds the lower one; the dorsal fin has become much more elevated, and, with the anal fin, is already furnished with rays; and the ventrals have become developed into long styliform appendages. A third specimen, about 2½ inches (60 millim.) long, has already acquired nearly the form and proportions of the adult; the upper jaw is considerably produced beyond the apex of the lower one, and both jaws have lost their armature of teeth; the parietal spine has vanished, and the præopercular one is comparatively small, while the fins have attained pretty nearly the proportions which they have in the full-grown fish. The little animal is, in fact, an unmistakable Swordfish, and only requires a little further elongation of the beak formed by the upper jaw to be a close likeness of its parents.

The Garfish, forming the family Scomberesocidæ, and one species of which, the common Garfish or Greenbone (*Belone vulgaris*), may not unfrequently be seen in the fishmongers' shops, present phenomena of development to some extent analogous to those observed in the Swordfishes. The adult fish has both jaws most curiously prolonged into slender-pointed beaks, of which, however, the lower one is the longest; but in the very young fish, although the form and general character are very similar to those of the adult, there is not a trace of this singular prolongation. It soon begins to make its appearance, however, and the length of the jaws gradually increases until the mature form is attained. In the course of this development, the disproportion between the two jaws is for a time very considerable, especially in the common Garfish, which at one period seems to reverse the characters of the Swordfish, having the lower jaw produced into a long slender beak, while the upper one is not remarkably elongated.

The development of some fishes of the genus *Holocentrum*, a somewhat perch-like group inhabiting tropical seas, presents a contrast to that of the Swordfishes in another way,—the young fishes are furnished not only with opercular and cephalic spines, which afterwards disappear more or less, but also with a projecting beak from the upper jaw, which is often serrated, and sometimes forked at the apex, but which always vanishes as the fish approaches maturity. These young forms of *Holocentrum*, and of the allied genus *Myripristis*, have been described as forming distinct genera under the very appropriate names of *Rhynchichthys*, *Rhinoberyx*, and *Rhamphoberyx*.

It would carry us too far to attempt to indicate anything like the whole of the phenomena presented by fishes in their development. We find in some special developments of the fins, or of parts of them, as in the case of the pectorals of the Flying Gurnards (*Dactylopterus*), and the separate filaments of the ventrals in the true Gurnards (*Trigla*); or certain of the fins undergo a change of position and function, as in the so-called Pediculati, of which the Fishing-frog or Sea Devil (*Lophius piscatorius*) may be taken as an example, in which, by an elongation of the carpal bones into a sort of arm, the pectoral fins, originally widely expanded, lateral organs, are converted into something very like feet, upon which the fishes rest and move about at the sea-bottom. The young Fishing-frog, in fact, although presenting a considerable family likeness to its parents, differs from them in some respects very remarkably. especially in the great development of the pectoral and ventral fins, in the curiously-branched structure of the free dorsal spines behind the filament which bears the so-called 'bait' immediately over the mouth, and the great elongation of the fin-rays in general, which are for the most part produced into long filaments. Similar filamentious prolongatons of some of the fin-rays occur in many other young fishes, and most strikingly in some of those curious inhabitants of deep water, the Ribbon fishes, the young of which are frequently captured at the surface, although the adults have never been met with there, except in a dead or dying condition. The young of *Trachypterus*, a genus of Ribbon fishes, examples of one species of which (the Deal-fish, *Trachypterus arcticus*) are generally thrown upon the northern coasts of Britain after the equinoctial gales, exhibits this prolongation of the fin-rays in a most striking manner. The adult fish, which may attain a length of six feet, and which has a body shaped like a thin, broad, tapering blade, has a dorsal fin extending the whole length of its back, but with the foremost portion, situated above the head, separated from the rest of the fin, above which it rises to a considerable height, being supported upon very long flexible spines. The pectoral fins are small; the ventrals, situated beneath them, long, and supported by few rays; whilst the tail terminates in an obtuse tip, from the dorsal surface of which the caudal fin rises, nearly at right angles to the long axis of the body. In the young *Trachypterus*, which is also a thin, flat-sided fish, having a dorsal fin running the whole length of its back, the caudal fin, which is considerably larger in proportion than in the adult, is set on the tail in the usual way; the rays in the front portion of the dorsal, above the head, are enormously prolonged, forming free filaments, extending to three or four times the length of the body of the fish, and having in their course numerous lappet-like dilatations; the rays of the ventral fins are also considerably produced.

Of course we have been unable to give more than a general indication of the nature of these remarkable external changes in this very rapid and imperfect sketch. But we must notice that in many cases changes occur in internal structure of quite as great importance as those to which we have alluded. Among other things, the dentition frequently undergoes most remarkable alterations, and this is a matter of great consequence in relation to systematic ichthyology, and especially to the interpretation of the fossil remains of fishes. In fact, we may say broadly that a great proportion of young fishes differ from their parents by characters which would be regarded as sufficient for the establishment of new genera and species, if occurring in adult fishes; and hence it will be easily understood that, with the fragmentary acquaintance that we necessarily possess of the fish fauna of the high seas, and even of the shores of tropical countries, great numbers of young forms have already been described as independent genera and species. The two distinguished ichthyologists whose names were mentioned at the beginning of this article, and from whose writings most of its materials have been derived, have already indicated a great number of important systematic changes of this kind, which must be made in consequence of the recognition of the facts here briefly and imperfectly described. But a study of these works shows that while considerable progress has been made, much more still remains to be done. The changes referred to appear to be most strongly marked in pelagic and deep-sea fishes, which are not only difficult to get, but naturally so widely distributed, that it is only by lucky accident, or by long-continued investigation, that we can hope to bring together the successive forms of a species so as to work out its development.

REVIEWS.

THE *CHALLENGER'S* VOYAGE.*

IN this handsome quarto volume we have the first instalment of the final report on the results of the great exploring voyage of the *Challenger*, and if the rest of the work answers to the sample, the country, and especially British naturalists, will have every reason to be satisfied with the outcome of this expedition. In the Provisional Preface to this first volume, Sir Wyville Thomson explains generally the plan of publication that is being adopted; and it seems excellently calculated to place the scientific results of the voyage in a convenient form in the hands of the public. These results naturally divide themselves into two series. One of these consists of the hydrographical details, and magnetic, meteorological, and other physical observations which naturally fell to the lot of the Naval Surveying Staff; and their reports, with the addition of Mr. Buchanan's investigations of the specific gravity of sea-water at various depths and under various conditions, will occupy two volumes of the series. The complete report is estimated to form fourteen or fifteen volumes, similar to the one now before us, so that twelve or thirteen volumes are left for the record of the doings of the Scientific staff. One of these is to be given up to the investigation of the recent deposits on the bed of the ocean and their bearing on Geology and Petrology, by Mr. John Murray and the Abbé Renard; and another, which is to be the final one of the series, to a discussion of the general chemical and physical results of the expedition; the zoologists to whom the collections made during the voyage have been confided will thus have ten or a dozen stout quartos in which to disport themselves, and enormous as the mass of specimens undoubtedly must be, we cannot help feeling that they ought to have room enough.

The Zoological contributions will make, according to Sir Wyville Thomson's statement, about fifty separate memoirs, and the mode of publication to be adopted is somewhat as follows:—Each memoir and its plates will be paged and numbered separately, and as soon as a sufficient number of memoirs has been collected to make a volume of the proper size, they will be at once printed, bound together, and issued with provisional title-pages and prefatory matter. Thus, while the work is in progress, the published part will always be in a state fit for reference, and those who choose may keep it always in its original form; but on its completion, fresh title-pages, tables of contents, &c., will be issued, in order that the different memoirs may be brought into regular systematic sequence, according to the nature of their contents. An inconvenience which would naturally arise from this rearrangement, namely, the loss of all indications of date of publication, has been obviated by a very simple plan,—each separate memoir will have its own number as part of the report on the Zoology of the *Challenger* Expedition, and each sheet will have at the foot of its first page the indication of the part to which it belongs and the date of publication of that part. Volume I., now published, contains six parts, thus numbered consecutively.

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* *Report on the Scientific Results of the Voyage of H. M. S. Challenger, during the years* 1873–76, *under the command of Captain George Nares, R.N., F.R.S., and Captain Frank Turle Thomson, R.N.* Prepared under the superintendence of Sir C. Wyville Thomson, Knt., F.R.S., &c. 'Zoology,' Vol. I. Published by order of Her Majesty's Government. 4to. London, 1880.

In his general introduction to the *Challenger* Reports on Zoology, with regard to which, he says, he must be considered only in the light of the Editor of the whole work, Sir Wyville Thomson describes the general objects and arrangements of the Expedition very much in the same terms as in his previous book, giving an account of operations in the Atlantic, and then proceeds to discuss generally the nature and distribution of the fauna of the deep sea. The abyssal region extends, according to him, from a depth of 500 or 600 fathoms to the bottom of the deepest abysses, and so far as the results of recent explorations go, there is no bathymetrical limit to the extension of life downwards. At the same time, from the *Challenger's* dredgings it would appear that the abyssal fauna is richest between 600 and 1000 or 1200 fathoms, below which depth there is a gradual falling off, although living organisms were procured from the greatest depth at which the dredge was used. From 2000 fathoms downwards, however, the fauna usually becomes more sparse.

With regard to a matter of considerable interest, namely, the asserted absolute darkness of the abysses of the ocean, we are glad to see that Sir Wyville Thomson speaks with some reserve. He says, 'So far as we can judge, direct sunlight does not penetrate to great depths;' and he assumes that in the case of those abyssal fishes which have greatly developed eyes, those organs have been exaggerated to catch the last feeble rays of light coming from above. The notion that deep-sea animals see by the phosphorescent light emitted by thousands of their neighbours, he dismisses as altogether untenable, although he believes that abyssal creatures are phosphorescent in their native abysses, which does not appear to us to be proved.

The striking uniformity of the abyssal fauna everywhere, due, of course, to the equally striking uniformity of the conditions of life, leads Sir Wyville Thomson to regard it as representing a very ancient fauna, and in this respect no doubt he is right; but we are by no means inclined to accept the inference that therefore the present oceans are of great antiquity. Continuity of conditions in such a case does not at all of necessity imply identity of place; and we can quite conceive of the occurrence of an absolute continuity of abyssal conditions, without the assumption that since the close of the Palæozoic epoch, as seems to be implied by Sir Wyville Thomson, the great oceanic depths have approximately held the same position on the surface of the earth. Geological facts seem also to stand in the way of any such assumption.

As we have already stated, the present volume contains six out of the fifty memoirs in which the zoological results of the expedition are to be reported upon. There are some of the other memoirs, to the appearance of which we look forward with more interest than those here published, from the very nature of the objects to be treated of in them, such as the Corals and Hydroids, the Echinoderms, the Medusæ, the Sponges, &c.; but we can hardly hope to get more finished and complete treatises than those now before us.

The first of them is by Mr. Thomas Davidson on the Brachiopoda collected during the voyage; and when we say that it possesses all the characteristics of that gentleman's well-known work, the reader will understand that it is a most valuable contribution to the knowledge of the class of which it treats. The number of species obtained was not very great; indeed, Mr. Davidson seems rather disappointed that he had not more materials to work upon. There were in all 107 species, and of these comparatively few were from great depths. In his remarks on their bathymetrical distribution, Mr. Davidson shows, indeed, that the Brachiopods constitute but a small element in the abyssal fauna,—57 of the species were procured at a less depth than 100 fathoms; and in 125 dredgings down to 600 fathoms they occurred about 25 times, while in 281 dredgings below 600 fathoms Brachiopods were brought up only 16 times. Further we find that 98 species occurred above 500 fathoms, 16 between 500 and 1000, 6 in the next 500, 4 between 1500 and 2000, and only 3 between the last-named depth and 2900 fathoms, the deepest dredging in which Brachiopoda were obtained. Many species have considerable range in depth, the most striking in this respect being *Terebratula vitrea* from 5 to 1456, *Terebratula Wyvillii* from 1035 to 2900, and *Discina atlantica* from 600 to 2425 fathoms. Before describing the species and important varieties of Brachiopoda in the *Challenger's* collections, Mr. Davidson makes some general remarks on the classification of those animals, and gives a most valuable tabular list of the known recent species, showing their habitats and range in depth, and indicating the species which also occur in the fossil state. Ten species have been described as now, and these, with many of the others, are figured in four plates drawn, as usual, by Mr. Davidson himself.

Prof. von Kölliker's report upon the Pennatulida is scarcely so elaborate as the one just referred to; but it is also of much interest from the large number of new forms which the distinguished author has had to make known. The total number of species in the collections was 38, belonging to exactly half that number of genera; but of these, 27 species, and 7 generic types, are described as new. Further, the new types brought under his notice have induced the author to modify his classification of these Polyps (proposed in 1872), and he tabulates his new arrangement at the end of his paper.* Prof. Kölliker's memoir is illustrated with eleven plates very nicely executed in Germany under his own superintendence. Both the figures and the descriptions relate almost entirely to the external characters of the Polyps and their colonies, and there are very few anatomical details. As regards the geographical distribution of the group, Prof. Kölliker concludes that, so far as our present knowledge goes, the deeper portions of the oceans contain few or no Pennatulida at a certain distance from the shore. Some interesting facts have been ascertained about the geographical distribution of the families of Pennatulida, the most remarkable being the wide distribution of those curious forms the Umbellulidæ, long known as represented only by a single species from the Greenland coast. *Umbellulæ* have now been obtained from the temperate and equatorial Atlantic, from the ocean west of Kerguelen's Land, from the South Polar Sea, and from the coasts of New Guinea and Japan. As regards their distribution in depth, it appears that the higher forms (Pteroeididæ, Pennatulidæ, Virgularidæ, and Renillidæ), live in comparatively shallow water, only six species descending below 100 fathoms; while the less complex types forming the other families are, for the most part, inhabitants of deep water. These simple types are probably the oldest; and their most characteristic forms (Umbellulidæ and Protoptilidæ) have been shown by the investigations of the *Challenger's* naturalists to have a wide distribution.

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* As this may interest some of our readers, we have reprinted it in a slightly altered form in the *Scientific Summary*.

By that curious fatality in natural-history writings which so frequently makes the smallest things occupy the most space, Mr. G. S. Brady's report on the Ostracoda is by far the largest in the present volume, and we have no doubt that Count Custracane's account of the Diatomaceæ, Mr. H. B. Brady's report on the Foraminifera, and Prof. Häckel's on the Radiolaria, will worthily keep up the custom. With regard to the last-mentioned group, indeed, we have heard a report that Prof. Häckel counts his species by the thousand. Mr. Brady, having to do with objects visible to the naked eye, is more moderate; the species here described and figured by him are only 221 in number, but of these 142 are new, and three of them types of new genera. As regards the bathymetrical distribution of these little Crustaceans, we must confess to sharing the disappointment of Mr. Brady at finding that they are exceedingly rare in abyssal depths; for when we saw the bulk of the report on Ostracoda we were in hopes that we should find described in it a host of species from great depths, such as might have acted an important part in the conversion of dead into living animal matter. But it seems that with the exception of a very few forms all the specimens submitted to Mr. Brady were obtained by dredging in comparatively shallow water or by the tow-net. From 29 dredgings below 500 fathoms only 52 species were obtained, and the number of individuals of these was but small; whilst below 1500 fathoms 13 dredgings furnished only 19 species. Mr. Brady describes the species of the group placed under his charge in systematic order, but for the purpose of indicating their geographical distribution he divides the stations at which dredging operations were carried on, and from which Ostracoda were obtained, into seven regions, and finally tabulates all the species collected during the voyage, and indicates their distribution in the different areas. A further aid to the student in this direction is to be found in the list of localities with the species found in each, which follows immediately upon this table. Some few species are very widely distributed: thus two species of *Halocypris* occur in all Mr. Brady's seven areas, whilst two species of *Cythere* are found respectively in five and six of them; the latter are deep-sea forms. Very few can be identified with known fossil species. The Report on the Ostracoda is magnificently illustrated with forty-four plates, the figures in which have been most beautifully executed by Mr. W. Purkiss, and an inspection of these will enable the reader to form some conception of the laborious and minute research that Mr. Brady must have devoted to these little carapaces. A few details of structure illustrative of generic characters are given in some of the plates, the only defect in which seems to us to be that they have no indication of the natural size of the objects, or of the magnifying power under which they have been drawn. As the figures are enlarged from 30 to 60, and sometimes 80 diameters, an intimation of the amount of the enlargement ought to have been given.

Prof. W. Turner seems to have had some very unpromising materials in the bones of Cetacea which were handed over to him for investigation, and he has apparently made about as much of them as could well be expected. The most important specimen was a young skull of *Mesoplodon Layardi* from the Falkland Islands, which has enabled the author of this report to furnish some interesting details as to the formation and structure of the teeth in this imperfectly known Cetacean. Other specimens belonging to the same species were obtained at the Cape, the Chatham Islands, Australia, and New Zealand, so that the species seems to make the circuit of the Southern Hemisphere. The skull, cervical vertebræ, and sternum of the young animal, and sections of its teeth and of those of the adult are figured. Some details of the structure of Hector's *Epiodon chathamiensis* are given, and the species is identified with *Ziphius cavirostris*. A great number of tympanic bullæ and fragments of other bones dredged up in various localities are also described, and some of them figured.

Prof. W. K. Parker contributes the first part of an elaborate memoir on the embryonic development of the Green Turtle (*Chelone viridis*), in which he deals solely with the development of the cranium, face, and cranial nerves. Mr. Parker points out certain resemblances and differences between the Turtle and other Reptiles and the Batrachians, and indicates that the great number of somatomes in the neck and tail of the early embryo would seem to 'suggest an ancestry having a longer neck and tail than the existing forms;' and he goes on to remark that 'as some of the cretaceous Chelonia certainly possessed teeth, and as a few forms, both fossil and existing, have the nasal bones distinct from the prefrontals, it is evident that the modern Chelonia are forms that have become differentiated from their nearest reptilian relations by specialization. A long-necked ancestry, with a feebly developed carapace, and many feeble bones of the plastron arranged triserially, would bring us very near to the Plesiosaurs.' This report is illustrated with 15 plates.

Finally, we have Dr. Günther's excellent report upon the Shore-fishes, in which he describes the littoral fishes collected during the voyage, with the addition of the few freshwater forms that were taken. Dr. Günther tells us that he had 1400 specimens, representing 520 species, out of which 94 were new. He has treated the species in faunas laid down and divided upon a somewhat elaborate plan, but for the convenience of reference in determining species he has appended to his memoir a systematic list of all the species with references to the pages on which they are described or referred to. Of the new species a considerable number are Rays. Fourteen new genera are established, and among these forms of Pleuronectidæ seem to be most numerous. The plates, thirty-two in number, illustrating this report, are most admirably executed, and display the beautiful or grotesque characters of the fishes very clearly.

We have felt it a duty to enter in some detail upon the consideration of this volume as being not only in itself a repository of most valuable materials, but also, we may hope, the precursor of others, at least not less rich in interest and information. The zoological Reports of the *Challenger* expedition, if carried out throughout in the same spirit, will certainly bear comparison with any work of the kind. We may add that the volume is issued at a very moderate price, and that the different memoirs may be purchased separately. Also that the sale has been entrusted to several publishers in London and elsewhere.

ELEMENTS OF ASTRONOMY.*

THIS is one of the new volumes of Longman's Text Books of Science adapted for the use of students, and is a work therefore which should give a full and explicit treatment of its subject, so as to enable its readers to obtain a sound knowledge of the elements of the branch of Science to expounding which it is devoted. Above all, the information it contains should be trustworthy, and carried up to recent date. It cannot be said that this volume fulfils these ends. It is a very unsatisfactory work, as nearly every section shows evidence of inexperience and want of familiarity with its subject; all the more surprising as the work is from the pen of the Royal Astronomer for Ireland, and the head of the principal Observatory therein, that of Dunsink.

The work is divided into twelve chapters and some 273 sections, each section treating of its subject in the semi-isolated form so customary in mathematical text-books in common use at the Universities. These sections are badly arranged, those devoted to analogous subjects being often widely separated; and they are commonly devoted to the lengthy exposition of subjects which seem to indicate a strange inexperience of the requirements of astronomers. At times several pages are given up to the elaborate treatment of unimportant matters, whilst subjects of far more importance are dismissed in a few lines. Again, a subject is introduced and partially discussed, only to be taken up again and re-discussed at another time. Further, at times essential points are baldly stated and required to be taken on trust, whilst the minor points connected with them are made the subject of elaborate geometrical discussion. All these are grave faults in a work designed for students.

In many instances remarkable inexperience is shown in the quotation of authorities and data, as if the author was unaware of their merits; in many cases old and untrustworthy results are quoted, and more modern and accurate results ignored. Thus, on page 261 we find Schröter (Epoch, 1780–1810) quoted as the authority as to the density and refraction of the atmosphere of *Venus*, whilst the author ignores the only trustworthy results, those of Mädler (1840–1850), and Lyman (1865–1875), though they prove Schröter's results to be erroneous. Again, the author (pages 183 and 290) quotes and makes use of the value of the solar parallax derived from the transit of *Venus* of 1874, and published in the Report of the Astronomer Royal, ordered to be printed by the House of Commons, July 6, 1877, though it is well known that this result is valueless. It has, in fact, been practically abandoned even by its author. No reference whatever is made to the later results obtained by Major Tupman, nor to that found by Mr. Stone. In the last chapter, headed 'Astronomical Constants,' and occupying some ninety pages, there are innumerable cases of this inexperience as to what are trustworthy results and what are valueless, though accuracy in these data is of the most enormous importance to students. Time after time we find a long list of old results quoted—results a few of which may possess a little interest as curiosities, though of no value to Astronomy, whilst many of the most important modern determinations, often in fact the very determination in general use, are completely ignored. Thus for the obliquity of the ecliptic the only two modern values are Leverrier and Airy, and for Precession, Struve and Leverrier; Nutation and Aberration fare better. In the solar parallax we have Encke's earlier result only; Leverrier's early result, given as derived from 'the parallactic equation of the Moon:' Hansen's earlier and erroneous value only, and Tupman and Stone from the transit of *Venus;* and Downing and Hall from the observation of *Mars* completely ignored. For the planets we have Leverrier's elements given, but mostly with wrong epochs. The diameters without Young's value for *Mercury;* Plummer, Hartwig, and Auwers, for *Venus:* Ellery, Encke, Galle, Pritchett, for *Mars*, &c. For the value of the secular acceleration in the motion of the Moon we do not find either Adams or Delaunay's latest theoretical values, nor Hansen's last value from observation; but we do find Airy's last value, now admitted by its author to be erroneous, and one which was generally known to be erroneous from the very day it was published. In the values for the lunar parallax we find no reference to Adams, Breen, or Hansen. For the semidiameter the only modern value is that from the eclipses of 1860 and 1870, and all unnoticed are Burckhardt's, Plana's, Pierce's, Hansen's, and the Greenwich values. Under the head of the Lunar Equator we find either the lunar crater Manilius treated as an observer of the Moon, or the lunar observer Nicollet treated as a lunar crater, or perhaps both; and the results which Nicollet deduced from observations of the spot Manilius made by the astronomers, Arago, Bouvard, and Nicollet, are assigned first to Poisson and then to Plana. The section on the figure of the Moon is in helpless confusion, and hopelessly wrong. In the section on the Topography of the Moon, we find no reference to either Lohrmann's important map or his sections; and even Beer and Mädler's *Der Mond* is omitted, whilst Sir W. Herschel's 'Astronomical Observations relating to the Mountains of the Moon' is carefully inserted. This list must be enough, and yet we have only run lightly over a third part of the ninety pages of this chapter.

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* *Elements of Astronomy.* By Robert Slawell Ball, LL.D., F.R.S. Andrews Professor of Astronomy in the University of Dublin, Royal Astronomer for Ireland. 8vo. London, Longmans, 1880.

It would be impossible in the space of this short review to indicate more than a small fraction of the total number of imperfections which we have noticed in looking through the volume. On page 16 we find it stated that the mirrors of reflecting telescopes are usually made of speculum metal, though of late years excellent mirrors have been made of silvered glass, whereas there has been scarcely a mirror made of speculum metal for a quarter of a century, and over ninety-nine per cent of the reflecting telescopes in use have silver-on-glass mirrors. Pages 79 to 88 are devoted to the transit instrument and its corrections, though the very lengthy account would be quite insufficient to enable any one to take and reduce a transit, and it contains an extraordinary definition of the error of collimation,—the axis of collimation being defined as the line from the centre of the object-glass to the intersection of the central cross wires! Towards the end we have a selection of star catalogues given as the most generally useful: these are the British Association Catalogue! Argeländer!! and Lalande!!! Not a single catalogue from which a decent star-place could be derived, and all based on observations made near the beginning of the century! On page 233 we are favoured with a peculiar description of the lunar mountains, and the so-called lunar craters are spoken of as the nearly extinct craters of once active volcanoes, and as being several hundred in number! The illustration given as that of a typical lunar crater is curiously unlike anything on the face of the Moon. The picture of the Moon would not be so bad did not the shadows give rise to the question whether there were not two suns shining on it. The author also speaks of the absence of any penumbral fringe to the border between light and darkness on the Moon as proving the absence of any sensible atmosphere, whereas the actual existence of a broad penumbral fringe is well known to every lunar observer; and it is also known that no possible atmosphere on the Moon would produce such a broad fringe of this nature. On pages 115–123 we find a long account of the parallel-wire position-micrometer and its use, but no account of how the position-angles are to be determined, or even what they are. Later (page 332) we are told what a position-angle is, but not in what direction it is measured, so that the earlier information is useless. On page 326 we are told that 'it is at present, at all events, quite out of the question to suppose that a quantity so minute as the Sun's diameter could be detected by our instruments:' a startling statement, followed as it is by the addition that even were it ten times as great, it would be barely appreciable. It is to be trusted that the context will show the student that this means 'if the Sun's diameter seemed two hundred thousand times smaller than it does to us.'

The whole character of the book may be summed up as a little badly selected astronomy very diffusively treated with the aid of elementary geometry—a work neither sufficiently trustworthy nor sufficiently complete for the purpose it aims at. Its principal virtue is the clear and lucid manner in which it is written, the distinctness with which the various mathematical principles are enumerated, and the capital index with which it is furnished. As a text-book of Astronomy, however, it is certainly not to be recommended to any one wishing to obtain a full and trustworthy account of Modern Astronomy.

GEOMETRY.*

THIS work is intended for students wishing to gain such a knowledge of the principles of Practical Geometry as shall be useful to them in the drawing-office or the workshop. It contains under the heads of Practical Plane Geometry, and Orthographical Projection or Solid Geometry, numerous examples of the different problems arising in the study of geometrical drawing, the methods of solution being given with considerable detail, and very fully illustrated. Most of the cases are representative of such as have actually occurred during the author's class-teaching, and a large number of the examples given for practice are selected from the examination papers of South Kensington and the Indian Engineering College. A principal purpose of the work, as announced on the title-page, is 'to meet the requirements of the higher stages in the Science and Art Department Syllabus,' and this it is certainly well adapted to do, as any student who had carefully studied it might be expected to take a good position in the South-Kensington examinations. The excellence of the work for this purpose will, however, make it somewhat disappointing to those who may look into it for information on other than the simpler kind of knowledge required by elementary students; and it may be regretted that the author has found it necessary to restrict his work so closely within the limits of the Syllabus. For example, there is practically nothing about perspective projections, the only information given under this head being confined to a few pages on isometric projection, which is treated merely as resulting from a peculiar property of the cube, instead of being a representative, and that the least valuable one, of the class of axonometrical projection, the more important monodimetric and anisometric kinds being not even mentioned by name. The statement that isometric projection is only applicable to rectangular solids is unfortunate, as one of the few useful applications of this kind of drawing is in the delineation of the workings on mineral veins which are solids of more irregular curvature than any that it is probably ever necessary to represent in any other branch of industrial drawing.

In going through a work such as the present, the question is forcibly presented as to how far the working of complex cases of oblique projection, of intersecting solids of the most irregular character, such as are presented in its pages, is necessary to make a good mechanical draughtsman. The author tells us 'that an ignorance of projection must be a fatal impediment to success in the workshops.' This contrasts somewhat amusingly with the experience of one of our most scientific mechanical engineers, Prof. Fleeming Jenkins, F.R.S., who in his presidential address at Edinburgh, in 1871, speaks of 'the little *quasi* mechanical drawing which is taught' (under the Science and Art Department scheme) 'as mostly mere geometrical projection, a subject of which real draughtsmen very frequently, and with little loss to themselves, are profoundly ignorant. Descriptive geometry and geometrical projection are nearly useless branche f the art, and the little encouragement that is given is almost monopolised by them.'

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* *Practical Plane Geometry and Projection.* By Henry Angel. 8vo, with 4to Atlas of Plates. Wm. Collins, Sons, and Co. (Limited.) London and Glasgow. 1880.

In many, probably in most cases, time might be more usefully spent in making measured drawings from actual working objects, when once the elements of plane geometry have been mastered, than in solving the most ingeniously contrived examination puzzles in projections. This view of the subject appears to prevail in France, judging from the albums exhibited at the late Universal Exhibition, containing drawings made in the schools attached to the larger collieries, smelting and mechanical engineering works. There the works done by children from about twelve years of age upwards were for the most part representations of objects in common use in the works, from the simplest elements to tolerably complicated combinations, such as small steam-engines or simple tools, but in all cases the drawings were made from the real objects.

BELFAST LOUGH.*

A BOOK on the natural history of Belfast by a Robert Patterson, and dedicated to the memory of Robert Patterson, ought to be of interest to naturalists; and the volume before us on the Birds, Fishes, and Cetaceans frequenting the fine inlet of the sea which bears the name of Belfast Lough, will interest many readers. Mr. Patterson, indeed, does not pretend to be writing a profound scientific work: his work contains observations on the habits of the inhabitants of the Lough, made by him during the excursions of many years, and deals rather with the habits and manners of the animals referred to than with their description and classification. It is, in fact, especially as regards the Birds, a very pleasant, semipopular treatise, which may be perused with both entertainment and profit by the general reader, while at the same time, like so many other local books, it contains numerous bits of information which will make it welcome to the Naturalist. The statements as to fishing in the Lough are of much interest.

NORTH AMERICAN SEALS.†

JUST three years ago (*P. S. R.* January, 1878, p. 81) we called attention to the publication of Dr. Elliott Coues' monograph of North-American Mustelidæ; Mr. Allen's work on the Pinnipedia is a still more elaborate and valuable production. Seals, from their very nature, have, in many cases, a far wider distribution than can generally be enjoyed by terrestrial mammals; and hence Mr. Allen's investigations, although specially directed to the species inhabiting the shores of North America, necessarily range over a far more extended field, and deal with forms in which European naturalists have a direct local interest. Moreover, in discussing systematic points, questions of nomenclature, &c., our author does not confine himself to the species with which he has specially to deal, but treats of the group generally, referring also to the habits and natural history of species from all parts of the world, and thus his book is rendered indispensably necessary to every student of the Pinnipedia.

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* *The Birds, Fishes, and Cetacea, commonly frequenting Belfast Lough.* By Robert Lloyd Patterson. 8vo. London: D. Bogue, 1880.

† *History of North American Pinnipeds, a Monograph of the Walruses, Sea-Lions, Sea-Bears, and Seals of North America.* By Joel Asaph Allen. —*U.S. Geological and Geographical Survey of the Territories, Miscellaneous Publications,* No. XII. 8vo. Washington: Government Printing Office, 1880.

In the classification of the Pinnipeds the author introduces one new feature: he divides the sub-order into two great tribes,—one including the Eared Seals and Walruses, which have their hind feet turned forwards and walk upon all fours, which he calls Gressigrada; the other for the reception of the ordinary seals, which progress on land by the action of their fore-paws alone, assisted by wriggling motions of the body, and these are accordingly named Reptigrada. The groups seem to be natural enough, but we don't admire their names.

At the outset the reader is somewhat startled at missing the old familiar name of *Trichechus* for the Walrus, and finding substituted for it the very unfamiliar one of *Odobænus*. There is no doubt that it was by an inconceivable series of blunders that Linnæus, in the last edition of his *Systema Naturæ*, transferred the Walrus to the genus *Trichechus*, which belongs of right to the Manatee; but we question whether under the circumstances it was worth while to disturb the existing nomenclature. Mr. Allen distinguishes two species of Walrus, — the Atlantic Walrus (*Odobænus rosmarus*) and the Pacific Walrus (*O. obesus*),—and a very full account is given of their characters and natural history. Copies of the very curious old figures of the Walrus, taken from the late Dr. Gray's paper in the *Proceedings of the Zoological Society* (1853), show rather amusingly how very far the vivid imaginations of travellers and naturalists could carry them.

Mr. Allen discusses at considerable length the difficult question of the species of Eared Seals (Otariidæ), and comes to the conclusion that all the known forms may be referred to nine species,—five of which are Hairy Seals, or Sea-Lions (forming the sub-family, Trichophocaceæ), and four of them Fur Seals, or Sea Bears (Ouliphocaceæ). The general natural history of these animals is given in some detail, with a tabular synopsis of the genera and species, and the three species (two Sea Lions and one Sea Bear) which inhabit the Pacific coast of North America, are fully described from all points of view.

The Earless Seals (Reptigrada) form the single family Phocidæ, of which seventeen species are here catalogued by Mr. Allen, eight of them being fully described as inhabitants of North America. Besides these a ninth, somewhat doubtful species is noted as an inhabitant of the West Indies, and an occasional visitor to the southern shores of the United States. This seal (*Monachus? tropicalis*) appears to be known to the author chiefly from the descriptions of Hill and Gosse, who observed it in Jamaica.

Here, as indeed throughout the book, Mr. Allen has devoted the most unwearied labour to the accumulation of reliable information, not only with regard to the North American species, which may be considered the special objects of his study, but also in connexion with those which do not reside on the North American coasts, so that his work contains a summary of our present knowledge of the geographical distribution, habits, and synonymy of the living Pinnipeds, with most valuable notes upon the fossil forms which have been discovered in various parts of the world. The sections of the work dealing with the natural history of the Seals will be found most interesting, although, we believe, that most readers will feel their indignation rise at the descriptions of the proceedings of the seal-hunters, whose reckless destruction of unnecessary multitudes of these unfortunate creatures bids fair to extirpate some of them, at any rate, from the face of the earth. We had marked two or three passages for quotation, in order to show the extent to which these horrible massacres, sometimes attended with the grossest cruelty, have reduced the seal population of the Northern seas; but this notice has already reached too great a length. We can only express a hope that those who have power in their hands may, if possible, find some means of putting a restraint upon the operations of the sealers. Independently of the cruelty of such indiscriminate massacres as are to be found described in Mr. Allen's pages, and the loss to the world caused by the reckless destruction of seals which has so long prevailed, the unfortunate inhabitants of the Arctic shores, who are mainly dependent upon seal's flesh for their food, are rapidly diminishing in number owing to the increasing scarcity of this article of diet, and unless some change is made many tribes will perish off the face of the earth.

INFUSORIA.*

THE appearance of this book promises to mark an epoch in the history of our knowledge of the Infusoria perhaps of more importance than any that have been made since the publication of the great work of Ehrenberg. Of course, as only one part of it is published, and this deals solely with the generalities of the subject, it is at present impossible to contrast the systematic work with that of Ehrenberg, or of any subsequent writer; but there are, even in this portion, sufficient evidences of careful, painstaking, and thoroughgoing work, to lead us confidently to expect that the descriptive section, when it appears, will also be of very high quality.

In the part now before us, Mr. Saville Kent opens with an historical sketch of the progress of the knowledge of the Infusoria, since the first discovered members of the class struck the startled vision of old Leeuwenhoek some two hundred years ago. His references to the principal authors are arranged in chronological order, and he indicates the characteristics of the work done by each of them, and the effects produced by their respective labours, especially upon the scientific conception of these microscopic creatures.

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* *A Manual of the Infusoria, including a Description of the Flagellate, Ciliate, and Tentaculiferous Protozoa, British and Foreign, and an Account of the Organization and Affinities of the Sponges.* By W. Saville Kent, F.L.S., &c. Part I. Super royal 8vo. London, David Bogue, 1880.

A second chapter treats of the sub-kingdom Protozoa, and the position to be assigned in its ranks to the Infusoria. Our author accepts the sub-kingdom Protozoa in the old, that is to say, the pre-Häckelian sense, including the Sponges, and altogether rejecting the 'kingdom' Protista. He defines the group 'as embracing all those forms of life referable to the lowest grade of the animal kingdom, whose members are for the most part represented by organisms possessing the histologic value only of a single cell, or of a congeries or colonial aggregation of similar independent unicellular beings.' His views of the classification of the Protozoa appear at first sight a little complicated, inasmuch as some of his primary sections overlap one another in the classes, or at least in the class Flagellata, which includes representatives of three primary sections, so that at present it is not very clear what classificational value is to be ascribed to the latter, although one can see the interest attaching, from a philosophical point of view, to the recognition of the peculiarities embodied in them. Thus, Mr. Kent, in establishing his primary groups, has regard, 'not so much to the varied character of the locomotive or prehensile appendages possessed by the representatives of this sub-kingdom, as to the nature of the oral apparatus or systems subordinated to the function of food-ingestion.' In the first and lowest of these sections food is 'incepted indifferently at any point of the periphery or general surface of the body;' these are called *Pantostomata*, and the Rhizopods may be taken as typical examples of them, although sundry flagellate Infusoria are included in the group. In the second section, although there is no true mouth, the inception of food is performed by a discoidal area occupying the anterior extremity of the body; these are the *Discostomata*, and they are represented by the collared flagellate forms and by the sponges. The *Eustomata* have a true mouth, and are best represented by the ciliated Infusoria; whilst the *Polystomata* include only the tentaculiferous forms, such as *Acineta*. The four classes of Protozoa, however, are characterized by their locomotive or prehensile arrangements,—they are the Rhizopoda, Flagellata, Ciliata, and Tentaculifera. With the first-named class the present work has nothing to do; the others will be treated in detail, and we have in this first part the general description of the structural and physiological characters presented by them.

As may be seen from a previous quotation, Mr. Saville Kent accepts unconditionally the view of the unicellular nature of the Infusoria; but simple as this makes them out to be, he finds a good deal to tell his readers about their structure and the functions of the comparatively few parts of which they consist. Throughout the section of his work dealing with the morphology of the Infusoria, we find him making full use of the results arrived at by previous observers, but these are checked in all cases by his own researches, which have been pursued most industriously for many years. The same thoroughness of treatment characterizes the exceedingly interesting section devoted to the consideration of the reproductive phenomena of these little creatures, and the important chapter in which the question of spontaneous generation is discussed. Here the author again adopts the historical mode of treatment; and, commencing with the results of the earlier observers, works up through the investigations of Pouchet and Pasteur in France, and of Bastian and Tyndall in England, to those of Dallinger and

Drysdale, and to his own researches upon the animalcules of hay-infusions, which in combination furnish a body of evidence against which the advocates of abiogenesis will find it vain to contend.

Mr. Kent further treats of the zoological affinities and distribution of the Infusoria, and gives directions as to the best modes of investigating and preserving them for examination.

The Sponges, as already stated, are placed by the author among his flagellate Protozoa as an order standing next to the collared Flagellata. He proposes to discuss in detail the much-vexed question of the true position of those remarkable animals, but in this first part of his book he only commences the chapter dealing with it. The chief reason assigned by Prof. Häckel for transferring the Sponges from the Protozoa to the Metazoa was derived, as is well known, from their mode of reproduction, the 'swarm-gemmules,' or ciliated reproductive bodies of the Sponges being developed according to him in the same fashion as the embryos of the higher animal forms. Häckel's results have not passed entirely without contradiction, and Mr. Kent declares that the developmental phenomena of the Sponges 'accord essentially and entirely with those presented by the typical Protozoa,' and 'that there is no formation of a germinal layer or true tissue structure in any period of their development.' In his next part the author will expound his views of sponge-nature in full detail; and he has already published in anticipation two plates illustrative of the structure and development of Sponges. The remaining seven plates are devoted to the illustration of the collared Flagellata, and the figures, like all those produced by the author's pencil, are exceedingly delicate and beautiful.

If carried out in the spirit in which it has been commenced, Mr. Saville Kent's *Manual of the Infusoria* will certainly be one of the most important books that we possess upon the subject of which it treats—a subject of interest to all philosophical naturalists, and of special interest to all the numerous workers with the microscope. It is to be published in six parts, and in the matter of execution, both as to text and illustrations, really leaves scarcely anything to be desired.

While this notice was passing through the press we received the second part of this book, but unfortunately too late to allow us to say anything about it.

THE ATOMIC THEORY.*

SINCE the early days of Greek philosophy, the hypothesis of the atomic constitution of matter has played no insignificant part in the history of physical science. It was not, however, until the beginning of the present century that the hypothesis took so definite a shape as to become an almost indispensable aid to scientific thought. To the genius of John Dalton unquestionably belongs the credit of having elaborated the old idea with such rare subtlety that the hypothesis has been elevated to the rank of a great theory. Prof. Wurtz, who startled us some years ago by asserting that chemistry is essentially a French science, is an ardent admirer of the theory which the English philosopher developed, and has written upon this subject a valuable work, which forms one of the recent volumes of the *International Scientific Series*. To say that the work has been admirably written is only to say what might be expected of anything that comes from the pen of so accomplished an author. Moreover, it is, on the whole, tolerably impartial, though we are inclined to think that the important work of Avogadro was deserving of fuller recognition. M. Wurtz's book falls into two parts—the first dealing with Atoms, and the second with Atomicity: the latter, however, is not treated so comprehensively as the former subject. After carefully looking through the book, we are unable to say where else, in the English language, the student will find so complete an exposition of the atomic theory in its bearings upon modern chemistry. It is a pleasure to add that the translator has rendered his author into admirable English.

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* *The Atomic Theory.* By Ad. Wurtz. Translated by E. Clemenshaw, M.A. 8vo. London: Kegan Paul & Co. 1880.

MEMOIR OF A YOUNG CHEMIST.

'WHOM the gods love die young.' The death of Thomas Wills, at the early age of twenty-eight, furnishes another illustration of this adage. Singularly amiable as a Christian gentleman, and highly accomplished as a chemical lecturer, Mr. Wills was esteemed and beloved by all who knew him. The work that he accomplished in his brief life was not only highly creditable in itself, but gave fair promise of a brilliant future. Mr. Wills was, originally, assistant to Dr. Odling at the Royal Institution, and afterwards became Demonstrator in Chemistry at the Royal Naval College. To reproduce his papers, as has been done in this work, was a fit tribute to his memory; but to write a biography of one who had so short a career was a matter of questionable expediency. However interesting the anecdotes of childhood may be to the family of the deceased, they are apt, in many cases, to give rise to a smile when read by a stranger. Nevertheless, we sympathize with the spirit in which the little volume has been written. The tenderness of a mother breathes warmly through every page, and the critic stands disarmed.

A SIMPLE BOOK ON HEAT.

THIS is an unpretending little work, put forth for the purpose of expounding, in simple style, the phenomena and laws of Heat. No strength is vainly spent in endeavouring to present a mathematical view of the subject. The author passes over the ordinary range of matter to be found in most elementary treatises on heat, and enlarges upon the applications of the principles of his science—a subject which is naturally attractive to the uninitiated. Mr. Williams's object has been well carried out, and his little book may be recommended to those who care to study this interesting branch of physics.

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* *The Life of Thomas Wills, F.C.S.* By his Mother Mary Wills Phillips, and her friend J. Luke. 8vo. London; James Nisbet & Co. 1880.

† *A Simple Treatise on Heat.* By W. Mattieu Williams, F.R.A.S., &c. With 26 illustrations. 8vo. London: Chatto & Windus. 1880.

ELEMENTARY CHEMISTRY.*

DR. KEMSHEAD'S elementary work on *Inorganic Chemistry* was originally written for the use of students preparing for the May examination of the Science and Art Department. That it has well served its purpose is apparent from the fact that it has now reached its second edition and twentieth thousand. When it first appeared it was notable as one of the earliest text-books in which Dr. Frankland's notation was adopted. The new edition has been corrected where necessary to bring it into accordance with the recent progress of chemistry.

TABLES FOR ANALYSIS.†

IT is not a very ambitious chemical feat to analyse, qualitatively, a simple salt. Mr. Vinter is teacher at the Leys School in Cambridge, where the pupils generally cannot spend, we are sorry to hear, more than one hour a-week in the work of the laboratory. As a guide to the method of examining a simple salt he has prepared these tables, which for the last four years he has found useful in his own class. They appear to be clear, concise, and accurate; and may therefore usefully serve the purpose for which they are sent forth.

THE GARDENS OF THE SUN.‡

THE GARDENS OF THE SUN is the somewhat fanciful name conferred by Mr. Burbidge upon the islands of the Malayan Archipelago, in some of which he passed some time collecting plants for Messrs. Veitch. Of their beauty he speaks in the most enthusiastic terms; and although in this respect he may be regarded as only confirming the statements of earlier writers, his account of his individual impressions is of interest, and may serve to give a new colour to the notions entertained by his readers.

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* *Inorganic Chemistry*. By Dr. W. B. Kemshead, F.C.S., &c. Twentieth thousand, revised and corrected. 8vo. London & Glasgow: W. Collins, Sons, & Co.

† *Tables for the Analysis of a Simple Salt, for use in School Laboratories*. By A. Vinter, M.A. 8vo. London: Longmans & Co. 1880.

‡ *The Gardens of the Sun; or, a Naturalist's Journal in the Mountains and in the Forests and Swamps of Borneo, and the Sulu Archipelago*. By F. W. Burbidge. 8vo. London: John Murray. 1880.

Mr. Burbidge gives a cheerful description of his voyage to Singapore, and of his experiences in that colony, including a visit to the neighbouring rajahdom of Johore; thence he proceeded to Borneo, and afterwards to the Sulu Islands and back; and everywhere he seems to have cast in his lot with the people in a hearty manner, which gave him many opportunities of observing their habits and modes of life. Accordingly the reader will find in this book many exceedingly interesting details with regard to the social condition of the inhabitants of the islands visited; whilst from the circumstance that, in Borneo especially, the author made long journeys into the interior of the country, he is enabled to give much information upon the inland tribes, which will be of value to the ethnologist. He notices the Jakuns, or wild men of the interior of Johore (chiefly from the statements of Dr. Maclay), and the Muruts, Kadjans, and other supposed aboriginal inhabitants of Borneo, who seem to have disappeared from the coast, or been absorbed by the Malays, whose characters are more or less evidently modified by the intermixture of native blood.

Naturally the plants of the localities visited by Mr. Burbidge attracted the greatest share of his attention; and in collecting these he appears to have been exceedingly energetic and successful. From the mountain of Knia Balu (the Chinese Widow mountain) he succeeded in sending living plants of the gigantic pitcher-plant *Nepenthes Rajah*, and also another very curious species of the same genus (*N. bicalcarata*), in which the pitchers are armed with two formidable spines, which the author believes to have the function of preventing insectivorous birds and mammals from reaching the insects always contained in those curious receptacles. Fifty species of ferns, about one quarter of which were previously unknown, were added by the author to the flora of Borneo; and in the Sulu islands he also collected a considerable number of plants of the same order. Lists of these, with short descriptions of most of the new species, are given in an appendix.

Plants did not, however, engage the whole attention of Mr. Burbidge, and many remarks upon animals observed are scattered through his pages. Nevertheless, zoology is not his strong point. Birds seem to have attracted him most, and he made collections of them both in Borneo and the Sulu Archipelago. Lists of the species obtained, with descriptions of some new forms, from the pen of Mr. Bowdler Sharpe, will also be found in the appendix.

THE POETRY OF ASTRONOMY.*

UNDER this title Mr. Proctor has issued another selection of his numerous contributions to our magazines during the last five or six years. Like all of Mr. Proctor's essays, these are well-written sketches of the more popular portions of the science of Astronomy; and if they will seem somewhat superficial to the more scientific of his readers, they will prove decidedly interesting and instructive to the larger class whom Mr. Proctor more especially addresses, and who have so repeatedly shown how much interest they take in Mr. Proctor's ingenious speculations.

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* *The Poetry of Astronomy: a series of familiar Essays on the Heavenly Bodies.* By Richard A. Proctor, B.A., F.R.A.S. 8vo. London: Smith, Elder, and Co. 1881.

The contents of the volume are separately entitled: 'Age of the Sun and Earth;' 'The Sun in his Glory;' 'When the Sea was Young;' 'Is the Moon Dead?' 'The Moon's Myriad Small Craters;' 'A New Crater on the Moon;' 'A Fiery World;' 'The Planet of War;' 'Living in Dread and Terror;' 'A Ring of Worlds;' 'Earth-born Meteorites;' and the 'Architecture of the Universe.'

Of these essays, the one we like best is that called, 'The Sun in his Glory.' The weakest one is that on 'The Moon's Myriad Small Craters,' because it is founded on a very imperfect acquaintance with the real nature of the lunar surface and especially of these very formations—small craters—to which he refers. Had they been of the nature supposed by Mr. Proctor, his extraordinary theory, that they are indentations of the surface due to the impact of large meteors, might be made to read plausible enough, but then they are not of the nature supposed, which is unfortunate for the theory,—or the Moon. Strangely enough, Mr. Proctor selects Prof. Newcomb as his authority for the nature of the lunar surface; though eminent as Prof. Newcomb is in his own departments of Astronomy, his acquaintance with the character of the Moon's surface is necessarily extremely superficial. Mr. Proctor's best essay, entitled 'A New Crater on the Moon,' illustrates one of the evils of this system of reprint essays; for however permissible it may have been at the time of writing, it is now known to be founded on a mistake as to the identity of the crater supposed to be new, and states as facts things now known to be quite erroneous. The two essays on the planet *Mars* will be found most interesting to the general run of readers, as they contain some very ingenious speculations.

SCIENTIFIC SUMMARY.

ASTRONOMY.

The Secular Acceleration in the Mean Motion of the Moon.—In the Astronomical Summary of the last number of this *Review*, reference was made to a paper by Sir G. Airy on this subject, in which he arrived at results contradictory to those which had been admitted to be correct by all the great mathematicians of the day. At the same time it was pointed out that the result obtained by the Astronomer Royal was unquestionably erroneous, his investigations being vitiated by fundamental errors. The supplementary number of the *Monthly Notices of the Royal Astronomical Society* contains a further paper by Sir G. Airy, in which, by rectifying most of these errors, he arrives at the same result as that found by Prof. Adams, and which has been now admitted to be correct for nearly twenty years. Curiously enough, Sir G. Airy, in his last paper, does not acknowledge his error, except implicitly by giving results diametrically opposed to those of the previous paper.

Nautical Almanac for 1884.—This volume has been just published. Like the preceding volume, the places of the Moon have been derived from Hansen's Table with the addition of the empirical corrections deduced by Prof. Newcomb, and published in 1878. There may be some doubt as to the advisability of introducing these empirical corrections, for they have already commenced to deviate from observation.

Jupiter.—During the autumn the planet *Jupiter* has been giving evidence of considerable activity, and a large number of interesting observations have been made.* The famous red spot has faded in colour, and is no longer so vivid as during last year, though it is practically as large and as conspicuous. Quite lately, however, it has shown traces of a woolly texture, not improbably the incipient signs of its gradual disappearance. Prof. Julius F. Schmidt, of Athens, has carefully discussed the observations of the time of transit of this spot across the apparent central meridian of the planet, with the view of determining the time of rotation. From the observations made during 1879, he obtains the value—

$$9^{\mathrm{h}}\ 55^{\mathrm{m}}\ 34^{\mathrm{s}}{\cdot}42$$

for the time of rotation, and from the observations made during 1880 he finds the value—

$$9^{\mathrm{h}}\ 55^{\mathrm{m}}\ 34^{\mathrm{s}}{\cdot}43$$

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* See also an article by Mr. W. F. Denning in the present number.

This coincidence is interesting, as last year it was thought that the motion of the red spot was gradually accelerating. From the total number of observations he derives the value–

$$9^{h}\ 55^{m}\ 34^{s}{\cdot}42 \ \pm\ 0^{s}{\cdot}04$$

This value differs by $8^{s}{\cdot}7$ from the result of the observations of the rotation of *Jupiter* made during 1862, when from the observation of a very permanent white spot there was derived the value

$$9^{h}\ 55^{m}\ 25^{s}{\cdot}68 \ \pm\ 0^{s}{\cdot}18$$

Of late a considerable number of white spots have made their appearance on the dark red equatorial belt. Some of them are beautifully round, and resemble satellites in transit, but others are more irregular, and have a woollier aspect. These white spots move considerably faster than the red spot, every day showing a marked gain. According to Schmidt, the time of revolution of these white spots is

$$9^{h}\ 50^{m}\ 0^{s}$$

So that they gain thirteen minutes per day on the red spot. This is confirmed by the results obtained by Mr. W. F. Denning, who finds the time of rotation of three of these spots to be $9^{h}\ 50^{m}\ 5^{s}$, $9^{h}\ 50^{m}\ 6^{s}$, and $9^{h}\ 50^{m}\ 3^{s}$ respectively.

Towards the middle of October a number of round dark spots, at times almost black, made their appearance in the northern hemisphere of the planet. These spots greatly increased in number, and towards the end of November they formed, according to Mr. W. H. M. Christie, a regular dark belt. From the observations of Messrs. Williams, Elger, and Denning, they seem to move with the same velocity as the equatorial white spots, having a time of rotation of $9^{h}\ 50^{m}\ 5^{s}$. According to Prof. Schmidt, however, some of the black spots move slower than the white equatorial spots.

Following the red spot there is a pale greyish spot, and also a whitish streak; both these seem to move with the same velocity as the red spot itself, so that it would seem that the variation in velocity affects the different belts as a whole.

At the present time, therefore, *Jupiter* presents an interesting subject for critical examination with large instruments, and a good deal may be expected to be learned when all the recent observations are critically discussed.

Hartwig's Comet.—This comet was discovered by Herr Hartwig at the Strasburg Observatory, on the evening of September 19, 1880, and by Prof. Harrington at the Ann Arbor Observatory on the following night. It was a bright comet, of considerable size, and for several days during the beginning of the month could be easily seen with the naked eye, being a little brighter than the well-known nebula in *Andromeda*. It was not discovered until more than three weeks after its perihelion passage, so that when seen it was quickly receding from the Earth, thus rapidly becoming fainter, and by the end of the month it had become so faint that it could only be seen in the most powerful telescopes. It was a bright diffuse comet, with a rounded nucleus, and a tail nearly two degrees in length.

Shortly after its discovery, Prof. Winnecke pointed out the strong resemblance between its orbit and that of the bright comet of 1506, and expressed the opinion that the two were probably identical. Later investigations confirmed this view, and showed that the comet strongly resembled in its orbit the comet visible in the years 1444 and 1569. It would therefore appear to have a period of some sixty-two years. Dr. Schur and Herr Hartwig, from their investigations, assign to the comet a period of 62⅓ years, and the following elements:

Perihelion passage, 1880, September 6·5894, Berlin mean time.

Longitude of perihelion	83° 33′ 28″
Longitude of ascending node . . .	44 33 30
Inclination of orbit	38 8 56
Eccentricity of orbit	0·97764
Semi-axis major	1·5756

The orbit of the comet extends, therefore, beyond the orbit of the planet *Neptune;* but owing to the great inclination of the orbit, it cannot be much affected by the perturbation of any of the greater planets. The comet, however, approaches very close to the orbit of the planet *Mercury* at the ascending node; and Prof. Winnecke is of opinion that it may be due to the attraction of this planet that the comet has been introduced into the solar system with its present elliptical orbit. For though at present the orbits do not approach each other sufficiently near to enable the planet to very importantly affect the motion of the comet, at some past period the two orbits may have been nearly coincident, though now separated by the effect of perturbation.

Swift's Comet.—On Monday, October 11, 1880, Prof. Lewis Swift, of Rochester, New York, discovered a large comet in the constellation *Pegasus*, but no observation seems to have been obtained during the month in Europe. On November 7, 1880, a bright comet was discovered at Dun Echt Observatory, belonging to Lord Lindsay. A day or two showed that the two comets were identical, and revealed in the constellation *Lacerta* that the orbit of the new comet coincided very closely with that of Comet 1869. This comet was discovered by Herr Temple, on November 27, 1869, in the constellation *Pegasus* a few days after its perihelion passage, and it was last seen at Leipzig on December 31st. On November 29, 1869, it was described by Dr. Vogel as a very faint object of considerable dimensions, being nearly 6′ in diameter. From observations spread over a month, Dr. Bruhns calculated a parabolic orbit, whose elements he found to be—

Perihelion passage, 1869, November 20·854, Berlin mean time.

Longitude of perihelion	41° 17′ 13″
Longitude of ascending node . . .	292 40 29
Inclination of orbit	6 55 0
Perihelion distance	1·1026

Dr. Bruhns remarked, however, that this orbit did not closely represent the observations, and seems almost to have suspected the elliptical character of the orbit. The close resemblance between this orbit and that calculated from the observations made of the comet of 1880 is shown by the elements for the latter comet calculated by MM. Zelbr and Hepperger:—

Perihelion passage, 1880, November	8·32198
Longitude of perihelion . .	42° 7′ 4″
Longitude of ascending node	295 36 54
Inclination of orbit . .	7 22 5
Perihelion distance . .	1·1019

There can be little doubt, therefore, about the identity of the two comets, so that it would give the comet a period of a little less than eleven years. This would give—

Eccentricity of orbit . . . = 0·7767
Semi-axis major . . . . = 4·9352

The orbit of the comet would approach, therefore, very close to the orbit of the planet *Mars*, and, what is of still more importance, within 0·5 of the Earth's mean distance of the orbit of the planet *Jupiter*, and not very far from the orbit of *Saturn*. From its mean approach to the orbit of *Jupiter*, and from the near commensurability between their periods of revolution, this great planet will produce very considerable perturbation in the motion of the comet.

Faye's Comet.—Since its discovery by Mr. A. A. Common, with his 37-inch reflector, at Ealing, this comet has been observed by Prof. Temple at Arcetri, by Dr. Duner at Lund, Dr. Pechüle at Copenhagen, and Herr Von Konkoly at O'Gyalla. The observed place corresponds very closely to the Ephemeris, and so affords a striking confirmation of the accuracy of the researches of Prof. Axel Möller. It is a very faint object, and scarcely within the reach of telescopes of ordinary aperture.

BOTANY.

Growth of Plants.—On December 16, Mr. Francis Darwin read, before the Linnean Society, two important papers, one on 'The power possessed by leaves of placing themselves at right angles to incident light,' the other entitled 'The theory of the growth of cuttings, illustrated by observations on the Bramble, *Rubus fruticosus;*' two papers which, though relating to different questions in the physiology of plants, have nevertheless much in common. Both of them bear on the relationship between the external and internal conditions of life; between external forces, such as light and gravitation, and the constitution of the organisms on which these forces act; and both tend to show the importance of recognizing in plants those specific forms of sensitiveness which may be said to determine the results which will follow external changes. We have to thank Mr. Francis Darwin and the authorities of the Linnean Society for the following abstract of these papers:—

I. The behaviour of leaves in relation to light may be illustrated by the cotyledons of a seedling radish; if it is illuminated from above, the cotyledons are extended horizontally, and are thus at right angles to the direction of incident light. If the seedling is then placed at a window, so that it is lighted obliquely from above, and if the stem (hypocotyl) is prevented from bending, the cotyledons will accommodate themselves to the changed conditions by movements in a vertical plane. The cotyledon which points towards the light will sink, while the other will rise; and thus both will become once more at right angles to the incident light.

Two theories have been proposed to account for this property of leaves. The first is that of Frank,* who ascribes to leaves, and to some other organs, a specific sensitiveness to light, called 'Transversal-heliotropismus,' or 'diaheliotropism.'† Just as an ordinary heliotropic organ has an inherent tendency to become parallel to incident light, so a diaheliotropic organ has an inherent tendency to place itself at right angles to the direction of the light. The two classes of organs differ from each other exactly as some creeping rhizomes do from ordinary stems; the rhizome tends to extend itself horizontally under ground, while the stem above the surface grows vertically upwards.‡

A different theory has been proposed by De Vries,§ whose views are supported by Sachs,‖ with additions or modifications. According to these views it is not necessary to assume the existence of any special kinds of heliotropism, since the phenomena might result from the ordinary forms of heliotropism and geotropism acting in concert. Thus, in the case of the seedling radish illuminated from above, if the cotyledons are apheliotropic (negatively heliotropic) and apogeotropic (negatively geotropic), it is possible that they might be kept in equilibrium by these opposing tendencies. The tendency to move away from a vertical light will make the cotyledons curve downwards toward the earth, and the apogeotropism, or tendency to move away from the centre of the earth, may exactly balance the downward tendency, so that the cotyledons remain horizontal. Besides the various geotropic and heliotropic tendencies, there are other modes of growth which may enter into the combination. In some cases there is a natural preponderance of longitudinal tension and growth along the upper surface of the petiole, so that, owing to impulses arising within the plant, there is a tendency for the leaf to curve downwards;¶ this tendency is called longitudinal epinasty, or simply epinasty: the opposite tendency is called hyponasty.

According to the theories of De Vries and Sachs, epinasty may be opposed by heliotropism, or by apogeotropism and geotropism, and all these opposing forces may combine in producing an equilibrium.

The object of the present paper is to test the relative values of the two above described theories,—that of Frank and that of De Vries and Sachs.

The method employed was to fix the plants under observation to a horizontal spindle, which was kept in slow rotation by clockwork. This instrument (called the 'clinostat') has been employed by Sachs for the study of ordinary heliotropism; light is admitted parallel to the axis of rotation, and the plants are thus subjected to a constant lateral illumination, while they are freed from the disturbing influence of gravitation; for, owing to their being kept in constant slow rotation, there is no reason why they should bend geotropically in one direction more than another.* On the same principle the behaviour of leaves which place themselves at right angles to the incident light has been studied. If a plant with horizontally extended leaves which has been illuminated from above, is fixed on a slowly revolving horizontal spindle, so that the axis of the plant is parallel both to the axis of rotation and to the direction of incident light, we shall have a means of testing the opposing theories above mentioned. The plant's leaves will still be illuminated by light striking them at right angles; therefore if Frank's theory is the right one, they ought to remain in this position. But if De Vries and Sachs are correct in their views, the leaves ought *not* to be able to remain at right angles to the incident light since geotropism has disappeared, which was one of the tendencies necessary to keep the leaves in a position of equilibrium. A considerable number of experiments were made with the celandine (*Ranunculus ficaria*), the results of which are decidedly in favour of Frank's views.

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* *Die natürliche wagerechte Richtung von Pflanzentheilen*, 1870.

† Darwin, *Power of Movement in Plants*,' p. 438.

‡ See 'Elfring,' in Sachs' *Arbeiten*, 1879.

§ Sachs' *Arbeiten*, i., 1872.

‖ Sachs' *Arbeiten*, ii., 1879.

¶ Or more accurately, in the direction in which the morphological lower side of the petiole is directed.

The leaves of the celandine are sometimes extremely epinastic, so that they press against the ground; and when a plant is dug up it often happens that the leaves, being released from the resistance of the soil, curve nearly vertically downwards. If such a plant is fixed on the clinostat in the position above described, the leaves will be pointing away from the light, so that if the leaves were apheliotropic, as might be expected according to De Vries' theory, the leaves would remain pointing away from the window. But this is not the case; they move forward until they are approximately at right angles to the light, and then come to rest. Again, if a celandine is placed in the dark, its leaves rise up so as to be highly inclined above the horizon; if the plant is then placed on the clinostat, the leaves (which now of course point towards the light) again accommodate themselves by curving backwards until they are at right angles to the light. Thus the leaves cannot be called heliotropic, or apheliotropic; we are forced to believe that under the influence of light they are able to move in either direction which may be necessary to bring them at right angles to the light. The other experiments with *R. ficaria*, the details of which we omit, lead to the same general result. Besides a few observations on *Vicia*, *Cucurbita*, and *Plantago*, a series of experiments were made on seedling cherries, and these lead to a somewhat different result. A cherry-plant, growing in the open air, has its leaves approximately horizontal, and when placed on the clinostat, as above described, the leaves are unable to remain at right angles to the light, but curve backwards, so as to become parallel to the stem of the plant. The petioles are shown not to be apheliotropic but to be powerfully epinastic, so that they move in the manner described when unopposed by apogeotropism.

It is clear, therefore, that the horizontal position of the leaves of seedling cherries growing normally, must largely depend on the balance struck between epinasty and apogeotropism, in accordance with the views of De Vries and Sachs. But since these forces obviously cannot produce the power of accommodating itself to the direction of incident light which the cherry possesses, we must assume that some kind of heliotropism enters into the combination.

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* See Sachs in his *Arbeiten*, Bd. ii., 1879.

The view to which the present research lends most probability is, that diaheliotropism (transverse-heliotropism) is the really important influence at work. In the case of the celandine we have seen that the sensitiveness to light is strong enough to determine the position of the leaves, although the natural balance is disturbed by the annihilation of geotropism. It seems probable that an essentially similar state of things holds good in the case of the cherry. When the plant is growing normally, it trusts to epinasty and apogeotropism to produce an approximate balance, the final result being determined by the stimulus of light; but when the balance is disturbed by placing the plant on the clinostat, the light-stimulus is not strong enough to produce a condition of equilibrium.

This view is the same as that given in *The Power of Movement in Plants*, and is in accordance with the principle there laid down,—that the chief movements in plants are due to modifications of the circumnutatory motion.

II. When a cutting—for instance, a piece of a willow-branch—is placed in circumstances favourable for growth, it produces roots at its lower end, while the buds at its upper end grow out into branches. The experiments of Vöchting [*] on the growth of cuttings were made by suspending pieces of stems and branches, &c. in large, darkened jars, the air in which was kept constantly moist by a lining of wet filter-paper. The cuttings were suspended both in the normal position, that is, with the upper end upwards, and also upside down. Vöchting found, as a general result, that there is a strong tendency for the roots to appear at the *basal* end, [†] and the branches to be developed at the apical end, whether the cutting had been hung apex upwards or downwards in the glass jar.

Vöchting believes that the growth of roots at the base, and of branches at the apex of a cutting, is determined chiefly by an innate inherited growth-tendency. When the knife divides a branch into two cuttings, it separates a mass of identically constituted cells into two sets; one forming part of the apex of the lower cutting, and another set which forms part of the base of the upper cutting. And under appropriate circumstances one of these sets of cells might develope into roots, the other into adventitious buds. It is Vöchting's belief that the morphological positions of these sets of cells, the fact of one being at the base, and the other at the apex of a cutting, chiefly determines the course of their subsequent development. The idea may be expressed somewhat familiarly, by saying that each cutting into which a branch is divided is able to distinguish its base from its apex, and can tell where to produce the growth of roots and buds, by means of an internal impulse which is independent [‡] of the external forces, gravitation and light.

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[*] *Organbildung im Pflanzenreich.* Bonn, 1878.

[†] The basal is that end of a cutting nearest to the parent plant; the apical end is the opposite end.

[‡] Vöchting states distinctly that gravitation and light do affect the positions in which organs are developed in cuttings, but he considers the internal impulse to be a stronger determining cause.

The theory which Sachs has brought forward in his paper on *Stoff und Form der Pflanzenorgane*[*] is entirely opposed to that of Vöchting. Sachs conceives that Vöchting's 'morphological force' is not a hereditary tendency, but a tendency produced by the action of external forces during the growth of the formative cells. Thus Sachs believes the force of gravity acting on the developing cells of an organ produces on it a predisposition or enduring impulse, which manifests itself in the results which Vöchting ascribes to a hereditary force. The mode in which Sachs believes gravitation to act is interesting, not only in itself, but also as a modification of a theory of Du Hamel's. It is assumed that difference of material is a necessary concomitant of difference of form, and that accordingly the materials from which roots are formed are chemically (used in a qualified sense) different from those which supply the branches. Sachs' theory supposes that the growth of roots or buds at a given place will be determined by the distribution of the root- and branch-forming materials, and that the distribution of these materials is regulated by the force of gravity. The root material is in a certain sense geotropic, and flows downwards, the branch material having the opposite tendency. But they are not supposed to be simply geotropic; the tendency of the root-material to flow to the base of a branch is carried on after the branch has been made into a cutting, and hung upside down, so that the root material flows upwards towards the base of the cutting, because that end was originally downwards, and *vice versâ* with regard to the branch-forming matter.

The observations on the bramble, which form the subject of the present paper were carried out with the object of deciding, for a particular case, whether the growth was determined by a morphological force, or by the after-effect of gravitation.

The long sterile shoots of the bramble are well known to possess the power of rooting at their ends. The terminal bud is thus protected during the winter, and the store of nutriment contained in the club-like thickened end of the branch forms a starting-point for new growth in the spring. It is commonly the long pendent branches growing vertically downwards that reach the ground and form roots. It might, therefore, be supposed that gravitation determines their growth at the *lower* end of the branch, just as, in a cutting made from an erect willow-branch, the roots grow at what was originally the lower end. But observations made on brambles under certain circumstances show that this is not the case. When brambles grow on a steep bank, the majority of the branches grow down-hill at once, or else straggle more or less horizontally along the bank, and finally turn downwards. But a certain number of branches grow uphill, and some of these take root at the apex. When, therefore, we find on the same individual plant some branches forming roots at the physically lower, and others at the upper end, we may feel sure that the distribution o root-growth in the bramble is not determined by gravitation or its after effect. We must believe that there is a morphologically directed impulse which tends to the production of roots at the apex of the branch, whether the direction of its growth has been upwards or downwards. It is true that in the observed cases the extreme end of the branches was bent, so that from 1 to 9 inches was inclined at from 2° or 3° to 5° below the horizon; but it can hardly be imagined that this fact influences the growth of roots at the apex, and experiment shows that it is not necessary that even a single inch should be inclined below the horizon. A bramble branch was tied apex upwards to a vertical stick, and was surrounded by damp moss, and covered with waterproof cloth; under these circumstances a plentiful crop of roots sprang from the terminal part of the branch. This result, combined with observations made with brambles growing on a steep bank, shows conclusively that an internal impulse or morphological force regulates the growth of roots in the bramble.

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[*] *Arbeiten des Bot. Inst. Würzburg*, 1880, p. 452.

When a cutting is made from a bramble, the only growth that takes place is the development of the axillary buds at the apical end of the cutting. Under certain circumstances these side shoots take on a root-bearing function. They are stunted in growth, being perhaps 10-12 mm. in length, and 3 or 4 mm. or more in breadth; they assume a peculiar club-like form, being thicker at the apex than at the base, and are clothed with rudimentary scale-like leaves, from among which a number of relatively large roots spring forth. In order to determine whether the production of this root-bearing type of shoot is determined by gravitation, or by a 'morphological force,' cuttings were made from branches whose direction of growth was above the horizon. Such cuttings were hung apex upwards, and it was found that the most apical buds were capable of developing, under these circumstances, into the root-bearing type of branch. Similar rooting side-shoots are produced by cuttings made from branches which have grown beneath the horizon, and it is therefore clear that gravitation is not the determining force in this form of root production. When the end of a branch is injured, as often occurs when a bramble grows along the ground near a pathway, the most apical bud or buds produce branches which take root, instead of the parent branch; either an ordinary branch is produced, which after a certain course of time makes roots at its extremity; or under certain circumstances the stunted, club-shaped, root-bearing side shoots may be developed, whose whole formation is devoted to the bearing of roots. It is therefore clear that the production of such shoots in cuttings is the same process that occurs in branches injured in a state of nature—a process which enables the branch to perform the function whose normal performance has been interfered with. And this fact enables us to see in what way a morphological growth-impulse is better fitted for the requirements of the case than any possible dependence on gravitation as a guiding force. When the end of the branch is injured, it is clear that if a branch is to be developed to carry on the function of the injured apex, it will have the best chance of success if it starts from the position already gained by the end of the original branch before it was injured. Therefore the bud which is nearest to the injured apex will be the most suitable one to be developed into a new branch. And this is equivalent to saying that the place where the new development is to take place is determined morphologically, and not by gravitation.

Thus in the bramble the behaviour of cuttings is a repetition * of the

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* See Vöchting, *Organbildung*, p. 107.

normal process of restoration of a deranged function in the plant; how far this is the case with other plants must remain at present undetermined.

Influence of Light upon Germination.—M. A. Pauchon has made a series of experiments to determine whether light has or has not any influence upon the germination of seeds. From various disturbing causes, his first experiments by the direct method gave no satisfactory results; he therefore adopted another plan, and compared the respiratory activity of seeds submitted to different conditions of light and obscurity, measuring by their absorption of oxygen. Taking identical parcels of seeds, of equal number and equal weight, he arrived at the following conclusions:

1. Light constantly accelerates the absorption of oxygen by germinating seeds. The advantage in favour of light varies from one quarter to one-third of the amount of oxygen absorbed by the seeds kept in the dark.

2. There is a relation between the degree of illumination and the amount of oxygen absorbed. The influence of light is very manifest under a clear sky and bright sun; with a cloudy sky it gradually decreases.

3. The acceleration produced by exposure to light persists for some hours after the exposed seeds are in the dark.

4. The difference in the quantities of oxygen absorbed in light and darkness are greater in winter than in summer; hence it would appear that the influence of light upon this respiration is more intense at low temperatures.

In a second communication, M. Pauchon gives the results of a series of experiments in which he determined the amounts of oxygen absorbed, and of carbonic acid exhaled, by identical parcels of germinating seeds in the light and in obscurity, thus ascertaining the different values given by these conditions to the fraction $\frac{CO^2}{O}$. His experiments were made upon two seeds of opposite types—the oleaginous and albuminous seeds of *Ricinus*—and the starchy and non-albuminous seeds of the Haricot. His conclusions are as follows:

1. The quantity of oxygen absorbed was, as before, always greater under the action of light. With the *Ricinus* the amount of carbonic acid exhaled was a little greater in obscurity than in the light; but with the seeds of *Phaseolus multiflorus* the result was different.

2. In obscurity the relation $\frac{CO^2}{O}$ was, with the Haricot at least $\frac{1}{3}$ above that ascertained for the *Ricinus*. With the latter it attains 0·58 in an experiment suspended on the fourth day, and 0·77 in one lasting five days. With the Haricot the relation is 1·14 in four days, and 1·03 after the sixth day. The prolongation of the experiments tends to render the relation $\frac{CO^2}{O}$ equal to unity, whatever may have been its original value.

3. Comparing the relation $\frac{CO^2}{O}$ in a single experiment, there is always in favour of darkness an advantage of about $\frac{1}{4}$ in the value of this relation, *i. e.* for the same amount of oxygen absorbed, seeds placed in darkness exhale more carbonic acid than those in light—sometimes, indeed, the absolute quantity exhaled in light is less than that set free in darkness. In the light there is always less carbonic acid exhaled than oxygen absorbed, and the reverse is the case in the dark.

4. These facts explain the conversion of legumine into asparagine. Asparagine in leguminous plants only disappears in plants exposed to the ight. Pfeffer's researches have shown that asparagine is poorer in carbon and hydrogen, and richer in oxygen than legumine and other proteic materials. The transformation of legumine into asparagine only takes place in the light, because this accelerates the absorption of oxygen, but his condition would not suffice if the carbonic acid exhaled were not less in quantity than the oxygen absorbed. A part of the oxygen, not represented n the exhaled carbonic acid, is probably fixed by the albuminoid principles during the formation of asparagine.—*Comptes Rendus, 26th October and 22nd November*, 1880.

CHEMISTRY.

The Liquefaction of Ozone and its Colour in the Gaseous State.—Ozone, such as one usually prepares, possesses so little tension in oxygen, at most 53 mm., that the physical properties of this body are hardly known and distinguished from those of oxygen. One knows the difficulties which Soret has so ably overcome in determining the density of ozone by operating on weakly ozonized oxygen. One of the fixed physical properties of this body is its heat of formation, which was accurately determined by Berthelot, in spite of the state of dilution in which it is found on leaving the apparatus for ozonization.

The preparation of a mixture, very rich in ozone, is then the first condition to be fulfilled in order to acquire new notions of this curious body. Hautefeuille and Chappuis have already established the fact that the isomeric transformation of oxygen submitted to electricity, obeys simple laws, and that the proportion of ozone increases but very little with the pressure for every temperature; whereas, in passing from 20° to −55°, the proportion of ozone increases five-fold. Removed from the action of electrical discharges, the mixture of oxygen and ozone ceases to be a homogeneous and balanced system; in spite of that, the mixture is preserved without appreciable alteration so long as a constant temperature is maintained, if we operate on it below 0°. This relative stability of ozone allows us to compress the mixture and to obtain the tensions of ozone of several atmospheres.

As it is necessary to prepare ozone, destined for these experiments, under the strongest possible tension, one must ozonize oxygen at a very low temperature. Consequently the oxygen remains a quarter of an hour in an apparatus of alternating discharges, whose concentric tubes of thin glass are dipped into chloride of methyl; then one passes it into a test-tube, terminated by a capillary tube of the Cailletet apparatus. This reservoir, of about 60cc, at first empty and kept at −23°, not being able to fill itself at one time under a pressure approaching 760 mm., is put rapidly in communication, five times successively, with the electric apparatus, the capacity of which cannot exceed 20cc. In a quarter of an hour, one succeeds by this method in filling the test-tube with a mixture of oxygen and ozone, very fully charged with the latter gas. The test-tube is then taken away from the chloride of methyl and separated from the electric apparatus, and the gas which it contains is driven slowly back by mercury, cooled to 0° in a capillary tube maintained at -23°. The mercury, which transmits the pressure of the hydraulic press, does not impoverish the gaseous mixture as quickly as one might fear. A solid glaze is formed on the surface of the metal which rapidly limits the action; the heating of the gas during the compression is more formidable. In spite of these difficulties one succeeds in increasing the tension of the ozone to a considerable degree. From the first working of the piston, the capillary tube becomes of an azure blue; this coloration is intensified in proportion as one reduces the volume of gas; and if the tension of the ozone is brought by the compression to be one of several atmospheres, the gas is indigo blue, and the meniscus of mercury, seen through the gas, is then of a steely blue. The blue colour of the gas becomes less intense, and the mercury regains its usual metallic appearance, as soon as one diminishes the tension of the ozone.

The preceding mixture contains enough ozone for one to observe a thick, white mist at the moment of the expansion which succeeds a compression of 75 atmospheres. It is not then necessary to compress the ozonized oxygen as much as pure oxygen (300 atmospheres) in order to determine by a sudden expansion the momentary formation of a mist, a certain sign of liquefaction or even of solidification.

A comparative study of the mixtures of oxygen and ozone, and those of oxygen and carbonic acid, shows that in very comparable conditions the expansion ought to be sensibly stronger with the ozone than with the carbonic acid, for one to begin to perceive a mist. Ozone would then be a little easier to liquefy than carbonic acid.

The mixture of oxygen and ozone contains an explosive gas, and should always be compressed slowly and cooled; for if one does not not meet these conditions, the ozone decomposes with an escape of heat and light, and there is a loud report accompanied by a flash of yellowish light.

Berthelot has found that the transformation of oxygen into ozone absorbs 14 cal., equivalent to 8 ($O^3 = 24$ gr.); ozone may therefore be placed beside explosive gases; the experiments show that, like them, this body is susceptible of sudden decomposition.

One may also observe a portion of these new facts by compressing oxygen which has gone slowly through the electric apparatus at ordinary temperature; for if we compress this gas rapidly in a capillary tube, placed in some water at 25°, we often destroy the ozone with explosion; but if this same gas is cooled at -23°, the ozone which it contains may be brought to a tension of 10 atmospheres, and may be preserved for hours in these conditions of temperature and pressure, if the gas is separated from the mercury by a column of sulphuric acid.

It is ascertained, then, almost equally clearly as in the preceding experiment, that ozone is a gas of a beautiful azure blue, for its colour is so intense when one increases its density tenfold, that it could be seen in a tube of 0^{m}·001 internal diameter, when operating in a very poorly lighted room in the laboratory of l'Ecole Normale.

It is therefore established that ozone under a strong tension is a coloured gas: but may the same be said of ozone at the tension of some millimetres? The blue colour characterizes ozone as surely as its smell; for at all the tensions we find it on examining the gas to a sufficient depth. It suffices in order to make this manifest, to interpose between the eye and a white surface a tube of 1 m. in length, traversed by the current which has passed through the electric apparatus of Berthelot. The colour which the gas then possesses reminds one of the blue colour of the sky; this blue is more or less deep in proportion to the time the oxygen has remained in the apparatus, and is consequently more or less rich in ozone. As soon as one stops the electric tube, the coloration disappears, the ozonized oxygen being replaced by pure oxygen.

Ice at High Temperature.—A short communication on this subject to the *Chemical News* by T. Carnelley (vol. xlii. 130) draws attention to the following points. Numerous experiments which have been made during the last weeks on the boiling-point of bodies under reduced pressure have led to the following conclusions respecting the conditions which are necessary for a body to exist in the fluid condition. They are as follows: (1) In order to convert a gas into a liquid, the temperature must be below a certain point —a point which Andrews termed the critical temperature of the substance; otherwise no pressure, however great, is able to convert the gas into a liquid; and (2) in order to convert a solid body into a liquid, the pressure must be above a certain definite point, which the author proposes to call the critical pressure of the substance: otherwise no temperature, however high, is able to convert the substance into a liquid. If the second condition deduced from the above is correct, it follows that, when the required temperature is reached, the conversion of the body into a liquid only depends on the pressure applied to it; so that if we keep the pressure on a substance below this critical pressure, no amount of heat will convert it into a liquid. In this case the solid substance passes directly into a gaseous condition; in other words, it sublimes without melting. When this conclusion is arrived at, it is easily seen that, if this representation is a correct one, it is possible to keep ice in the form of ice at temperatures which lie far above the melting point. After a great number of experiments which proved to be failures, Carnelley had the good fortune to attain the desired result, and to keep ice at so high a temperature that it was impossible to touch the tube which held it without burning oneself. This result has been obtained many times, and with great ease; and not only this, but in one case a small quantity of water was frozen in a glass vessel, which was so hot that it could not be touched by the hand without burning it. I have kept, he writes, a quantity of ice a considerable time at temperatures which lie far above the ordinary boiling point, and then it slowly sublimed away without first melting. These results are arrived at when the pressure is kept down below 4·6 mm. of mercury, that is to say, below the tension of aqueous vapour at the freezing point of water. Other substances show the same properties. The most remarkable is mercury chloride, because in this case the pressure need only be reduced to 420 cc. If the pressure be allowed to rise higher, the chloride immediately becomes liquid. In the case of water, there are certain details of manipulation which require attention, and which will be communicated in a second paper.

Guthrie's Cryohydrates.—When investigating the freezing-point of different salt solutions, Guthrie discovered some peculiar solid products to which he gave the name of cryohydrates. They are definite hydrates of the salts in question, which have a fixed solidifying and melting point, and in which he considers the salt to be in chemical combination with the ice. In 1877 Pfaundler showed, from theoretical considerations, that the properties which Guthrie found the cryohydrates to possess occur in the same way in the case of a mixture of ice and salt, and as such he regards the cryohydrates. Of the same view is H. Offer in a paper which contains the following conclusions against the existence of cryohydrates as chemical compounds. Against the possibility of a chemical combination existing in these bodies is the relative quantity of water found in them. The cryohydrates of NH_4Cl contain 12·4 of water; that of KCl, 16·61; that of $Na_2 CO_3$, 92·75; that of $K_2 SO_4$, 114·2 of water, and so on. He finds throughout numbers which give expression to no stochiometric law, and with much greater probability indicate mechanical mixtures. Furthermore, there is the circumstance that no cryohydrate, when becoming solid, furnishes a distinct definite crystal, which, as is well known, is quite characteristic of a chemical compound, but yields in each case an opaque, entangled, crystallized mass.

If cryohydrates are placed in alcohol, it is found that the ice is dissolved out of the substance, beginning of course with the outer layer; and the salt remains as a downlike shell of the inner unchanged cryohydrate; only after longer action did the entire mass fall to pieces. If, on the other hand, a cryohydrate is placed in water, the outer layer is, first of all, changed into transparent ice; this coating of ice increases at the cost of the cryohydrate kernel, step by step inwards, until at last the kernel vanishes, and a piece of ice the same size as the cryohydrate remains. Here the water has evidently gradually taken up the salt from out of the mixture. In the case of four different cryohydrates calorimetric determinations of the heat of solution were made, and the cooling observed in each case compared with those which, under similar conditions of temperature, salt and ice of the cryohydrate alone would furnish. In all experiments, the difference between the heat absorbed by the cryohydrates and by the constituents separately is so small, that they were within the errors of experiment, and may be estimated as nothing. Herr Offer determined the specific gravity of a number of cryohydrates, and compared them with that of their constituents, and in a whole series of cases found a pretty good accordance.

These results, while not fully proving the cryohydrates to be mere mixtures, yield results which, taken with the others above referred to, give to the assumption a great degree of probability. (*Sitzungsber. Wien. Akad. der Wiss.* 1880. lxxxi. 1058.)

Fire Extinction.—Some comparatives experiments have been made on a plot of ground adjoining the Savoy, Strand, with water and sodium silicate, as recommended by Herr Windsperger. Two piles of timber, 9 ft. long, 7 ft. high, and 4 feet deep, were filled in with straw, well saturated with petroleum and benzol in equal quantities, and ignited. After burning for five minutes, operations were commenced by throwing water on one, and sodium silicate on the other, with a handpump. In the course of about one minute the fire treated with the silicate was extinguished, while that treated with water did not give in till about four minutes. And it was further found that twelve gallons of the solution and twenty-two gallons of water had been used. The results of the experiment were most conclusive.

The Conditions attending Explosion.—It appears that when the rocket exploded during the second week of December at the Royal Arsenal, Woolwich, it was already fully charged, and the maximum pressure had been applied in safety. It is the custom, it seems, however, to leave the pressure on the rocket for one minute after reaching the maximum, and it had been so left for three quarters of a minute when the explosion occurred. The usual conjecture that such accidents are produced by an atom of dirt, the friction of the tamping tools, or any such causes, are therefore untenable in this case, and the origin of such explosions remains unknown. In future the rockets are to be filled and pressed in a bomb-proof room, and the men employed on the work are to be protected by iron shutters from any mishap.

GEOLOGY AND PALÆONTOLOGY.

Spirifer lævis, &c.—Prof. H. S. Williams communicates to *Silliman's Journal* an abstract of some researches made by him upon the *Spirifer lævis* of the Portage group of New York, and its relations to other forms occurring in other groups of Palæozoic rocks. His remarks are interesting as illustrating in a very remarkable manner the affiliation of so-called species in successive formations, detailed examples of which have rarely been so clearly put forward.

The more important characters of the species are distributed by Prof. Williams under the following seven heads:—(1) Form and proportions of the shell; (2) size; (3) prominence and over-arching of the beak; (4) the short and high cardinal area; (5) the triangular aperture covered by an arched pseudo-deltidium; (6) the smoothness (non-plication) of the surface; (7) the concentric series of minute radiating lines covering the surface. The last peculiarity has not previously been recorded as characteristic of the species, nor has it been noticed by writers on Devonian Brachiopods.

By careful comparison of characters, Prof. Williams arrived at the result that a genetic relationship exists between *Spirifer lævis* and *S. fimbriatus*, which occurs in the Hamilton and earlier formations. Then, tracing back the forms exhibiting the peculiar combination of characters which appeared to be essential to the two species just mentioned, he found the earliest trace of them in the Niagara formation at the bottom of the Upper Silurian. Here the central type of the primitive species is *S. crispus*, His., of which *S. bicostatus*, Hall, is probably an extreme variety, and *S. sulcatus*, His. an extreme variety in the other direction. *Spirifer crispus*, with corresponding varieties, is very abundant and very widely distributed, occurring at the horizon indicated wherever that is represented. The author also traced this type of Brachiopods forward to *Spirifer glaber*, Mart., and other Carboniferous forms.

The following is an abridgment of Prof. Williams' conclusions:—Whatever theoretical description we may give to species, we have here, in the first place, an abundance of organisms whose remains are found in Upper Silurian rocks of Europe and America, presenting a few clearly marked, distinctive characters variously developed in the individual forms, but so grading in the different varieties as to cause careful naturalists to associate them as varieties of a single species. There are well-marked typical characters, with great variability of the characters themselves. In the upper part of the Upper Silurian, we find the same typical characters, with a greater predominance of one or other of the variations; but yet, in the Corniferous and Hamilton, the main type is represented with some variations strongly marked and apparently fixed, but still recognized as varieties simply. In the Portage we see, under peculiar conditions, a solitary race with greatly exaggerated size; a luxuriant form, but still presenting the typical characters of the second varietal type. The same luxuriance of growth characterizes the Carboniferous forms; but the earliest form, *S. crispus* of the Niagara, possessed all the characters which afterwards appeared in the later representatives. Thus the whole may constitute a physiological species; but by intercrossing and by local conditions modifying the offspring, well-defined groups are produced, which would be called races if we knew their history, but which are called species because they appear at such widely separated geological periods. These separate groups, however, *develope no new characters;* and there is every evidence for the belief that the species has lived through this long geological time without losing its character, and that all that has resulted from great time and change of conditions has been the fixing into race-groups of the original variable characters of the species. The species, at its first appearance in the Silurian, presented a decidedly new combination of characters for the genus, and also much variation. When once these specific, though variable, forms appeared, they lived till the variations which could be played on them were exhausted; and the species ceased to live and became extinct, either near the close of the Carboniferous, or not till later in the Mesozoic. Prof. Williams gives the following table of the distribution of the forms above referred to in the American Silurian, and Devonian rocks:—

Chemung				præmaturus	
Portage					lævis
Hamilton			fimbriatus		subumbona
Corniferous			fimbriatus		
Oriskany		tribulis			
Lower Helderberg	N.Y. & Tenn.	Saffordi (pars)			
	Maryland			octocostatus	modestus
	New York	cyclopterus (pars)			
	New York		Vanuxemi		
Niagara	Shale			crispus	
	Limestone	sulcatus (pars)	crispus	bicostatus	

—(*Amer. Journ. of Science*, December, 1880.)

Grits and Sandstones.—Mr. John Arthur Phillips brought before the Geological Society, on the 15th December, a very interesting and valuable paper on the structural characters of grits and sandstones. He described the microscopic and chemical structure of a large series of grits, sandstones, and, in some cases, quartzites, of various geological ages, noticing finally several sands of more or less recent date. The cementing material in the harder varieties is commonly, to a large extent, siliceous. The grains vary considerably in form and in the nature of their enclosures, cavities of various kinds and *minute crystals of schorl* or rutile not being rare. Mr. Phillips drew attention to the evidence of the deposition of secondary quartz upon the original grains, so as to continue their crystal structure, which sometimes exhibits externally a crystal form. This is frequently observable in sandstones of Carboniferous, Permian, and Triassic age. Felspar grains are not unfrequently present, with scales of mica and minute chlorite and epidote. The author then considered the effect of flowing water upon transported particles of sand or gravel. It results from his investigations that fragments of quartz or schorl less than $\frac{1}{50}''$ in diameter retain their angularity for a very long period indeed, remaining, under ordinary circumstances, unrounded; but they are much more rapidly rounded by the action of wind. It is thus probable that rounded grains of this kind in some of the older rocks, as, for example, certain of the Triassic sandstones, may be the result of Æolian action.

Abnormal Geological Deposits in the Bristol District.—On the 17th November, Mr. Charles Moore read a paper on certain curious deposits in the country about Bristol, which may be regarded as a continuation of researches published by him some thirteen years ago upon similar phenomena in the districts of Somersetshire and South Wales.

The author remarked that the Frome district shows numerous unconformable secondary deposits and 'vein-fissures' resting upon or passing down through the Carboniferous Limestone, as described in his former paper (*Quart. Journ. Geol. Soc.* vol. xxii. p. 449). He gave some further particulars as to these deposits, and especially described the occurrence of Post-pliocene, Liassic, and Rhætic deposits in the *Microlestes*-quarry near Shepton Mallet. Here the lower part of a fissure is filled with a brown marl, containing crystals of carbonate of lime, and numerous remains of *Arvicolæ*, Frogs, Birds, and Fishes. The jaws of *Arvicolæ* were very abundant.

He then proceeded to describe the occurrence of similar phenomena in the Bristol area, as at Durdham and Clifton Downs, in the gorge of the Avon at Clifton, at Ashton and Westbury-on-Trym, in the Yate rock, in Nettlebury quarry, at Clevedon, and on the Thornbury railway. He noticed the occurrence in the infillings of fissures traversing the Carboniferous Limestone of these localities of fossil remains belonging to various geological ages; and he especially called attention to the presence in different deposits of an immense number of small tubular bodies of doubtful origin, for which, should they prove to be of organic nature, he proposed the name of *Tubutella ambigua*. By different authorities these little bodies have been assimilated to Serpulæ (*Filograna*), insect-tubes, and the casts of the fine roots of plants. With regard to the age of the fissure-deposits, the author remarked that although in some fissures the infilling shows a mixture of organisms, in most cases each 'vein' appears to have an individuality of its own, and thus the veins represent intervals of geological time clearly distinct from one another, different fissures showing infillings of Alluvium, Oolite, Lias, Rhætic, and Keuper beds. The presence of his *Tubutella* he considered to indicate fresh-water conditions.

The author also referred to the discovery of *Thecodontosaurus* and *Palæosaurus* many years ago at the edge of Durdham Down, and discussed the age of the deposit containing them, which was originally supposed to be

Permian, and was referred by Mr. Etheridge to the Dolomitic Conglomerate at the base of the Keuper. The author stated that he had found remains of the same genera in Rhætic deposits at Holwell and Clifton Down, and had hence been led to refer the two genera to that age. He stated, however, that he had since discovered teeth of *Thecodontosaurus* identical with those of the Bristol area in a deposit belonging to the middle of the Upper Keuper at Ruishton near Taunton, and recognized certain differences between these teeth and those of the same genus from the Rhætic beds of Holwell; hence he was led to give up the notion that the former were of Rhætic age, and to refer them to the Upper Keuper; but he remarked upon the interesting fact that, while most of the generic forms of the Keuper are represented in the Rhætic, the species differ.

A Cretaceous Snake.—Hitherto the first indications of the existence of Ophidian reptiles have been obtained from the earlier Tertiary deposits, especially the London Clay of Sheppey, from which Prof. Owen described two genera of these animals under the names of *Palæophis* and *Paleryx.* M. H. E. Sauvage has communicated to the French Academy (*Comptes Rendus*, 18th October, 1880) the discovery in the Charente of vertebræ of a snake in sandy deposits of the Cenomanian epoch; that is to say, of the age of our Upper Greensand. The vertebræ are about 14 millim. in length and are considered to indicate a serpent about 3 metres (10 feet) long. M. Sauvage briefly describes the characters of these vertebræ, in which he finds resemblances to Boas, Rattlesnakes, and Typhlopidæ, and especially to the the latter, which may be regarded as indicating the passage from the Serpents to the Lizards. He gives the new Cretaceous Ophidian the name of *Simoliophis Rochebruni*, in honour of its discoverer, M. Trémaux de Rochebrune.

MINERALOGY.

Spodumene and the Results of its Alteration.—This is the title of a fourth paper by G. J. Brush and E. S. Dana (*Amer. Journ. Sci.*, 1880, *October*, xx. 257), on the mineral locality at Branchville, Connecticut. Spodumene of this locality occurs in large masses, showing distinct cleavage, but seldom any approach to crystalline form. The blocks often weigh several hundred pounds. It is also found in an altered condition as nuclei of distinct pseudomorphous crystals, and one mass measured three feet in length, with a width of eight inches and a thickness of two inches. An analysis of a specimen gave the numbers:—

Silicic acid	64·25
Alumina	27·20
Iron peroxide	0·20
Lithia	7·62
Soda	0·39
Potash	Trace.
Ignition	0·24
	99·90

The lithia is in larger quantity than in specimens of spodumene from any other locality. As a result of the alteration of the spodumene, two substances were found, one, which the authors term β spodumene, which is made up of albite and a new lithium mineral, to which they have given the name of *eucryptite;* and the other is cymatolite, an aggregate of albite and muscovite. Eucryptite dissolves with gelatinization in hydrochloric acid and has the composition $Li_2\,Al_2\,Si_2\,O_8$, and the albite $Na_2\,Al_2\,Si_6\,O_{16}$.

The cymatolite received its name, in 1867, from Shepard, having been found at Goshen and Norwich, Mass. The specimens found by the authors of this paper have the composition:—

Silicic acid	60·55
Alumina	26·38
Manganese oxide	0·07
Soda	8·12
Potash	3·34
Lithia	0·17
Water	1·65
	100·28

This has the composition of one molecule muscovite and one molecule of albite, which is curious. With these minerals occurs microcline, having the composition:—

Silicic acid	64·55
Alumina	19·70
Potash	15·62
Soda	0·56
Ignition	0·12
	100·57

This is largely used for making porcelain; it is obtained in cleavage masses, as large as can be handled and nearly pure, a single continuous cleavage-surface ten feet long has been observed. After describing the killinite found associated with these minerals, we have some interesting speculations on the relations in method of occurrence between the various minerals produced by the alteration of the spodumene; and the genetic relation between the original spodumene and the various products of its alteration, concerning which we must refer the reader to the paper itself.

Peckhamite.—This name has been given by Dr. Lawrence Smith, of Louisville, Kentucky, to a new meteoric mineral occurring in the Emmet County meteorite. When broken, this mineral has a greasy aspect, and a more or less perfect cleavage, and its yellow colour has a greenish hue. In structure it differs widely from olivine, as may be seen under the microscope. Small rounded nodules, several millimetres in diameter, are found in the interior of the mass, sometimes of irregular form, from which fragments nearly pure can be detached. Its specific gravity is 3·23, and chemical composition was found to be:—

			Oxygen.
Silicic acid	49·50	49·59	25·73
Iron protoxide	15·88	17·01	3·77
Magnesia	33·01	32·51	12·76
	98·29	99·11	

The ratios above give very closely the formula, $2\ddot{\mathrm{Si}}\ \dot{\mathrm{R}} + \ddot{\mathrm{Si}}\ \dot{\mathrm{R}}_2$, being that of two atoms of enstatite or bronzite plus one atom of olivine. The mineral is named after Prof. Peckham, to whom the author is indebted for every facility in prosecuting his researches in connexion with this remarkable meteorite.

Examination of the Red Felspar of the Granite from Lyme, Conn.—A fragment of the beautiful coarse granite from the McCurdy quarry at Lyme, Conn., was given by Prof. Blake to M. Des Cloizeaux for optical study. He finds it to be a true microcline, but of an altogether peculiar structure, for the study of which the ordinary magnifying power is not sufficient, the constituent parts being exceedingly minute. The face of every cleavage shows a series of very small spots of albite, interspersed with hemitropic plates of microcline, the angle of extinction of which—not easily determined with great exactness—is 13° to 15°, measured from the edge between the two cleavage-faces. Across the second cleavage, the structure is, as it were, fibrous, and, with a high power, the angle of extinction is found to be from 7° to 9° for the microcline, and from 18° to 20° for the albite. 'I have never before,' he writes, 'met with a felspar with the elements so crowded together and so fine.' He hopes the proprietor may be able to supply some fragments of this beautiful granite. An examination of such specimens would be of great interest on account of the enormous size of its felspar individuals.—(*Amer. Journ. Sci.*, 1880, October, xx. 335.)

PHYSICS.

Effects of Magnetism on Iron and Steel.—According to some recent investigations by Prof. Righi on the effects of magnetism on iron and steel, (1) magnetism produces in iron and steel an increase of dimensions in direction of the magnetization. (2) On cessation of the magnetizing force a part of this increase remains, and more or less of it according to the coercive force. (3) The elongations are proportional to the square of the current's intensity when this is not very great. (4) When, after a strong current through the spiral, a weak current is sent in the opposite direction, it produces a shortening; but even when it is strong enough to demagnetize the bar, the latter retains a greater length than in the normal state. (5) During reversal of the polarity of a bar its length becomes momentarily less, and it oscillates in length. (6) A bar of wire or iron traversed by a current contracts at the moment of closing the circuit. (7) On opening the circuit it elongates, but this elongation is less than the initial contraction, indicating that transverse magnetism partly remains. (8) In reversal of the transverse polarity the bar elongates for a moment, and thus oscillates in length. (9) The contraction produced by a current is greater when the bar has before been longitudinally magnetized. (10) Some iron bars show a tendency to spiral magnetization, *i. e.*, to rotate the magnetic axes of their molecules in the direction of the spiral. This, says *Nature*, is shown by the contractions caused by a current passing through the bars, which are different according to the direction of the current and that of the previous longitudinal magnetization.

The Photophone has been reproduced in an exceedingly simple form by Mr. Shelford Bidwell. The transmitter is a disc of thin microscopic glass silvered on its anterior surface, and placed in front of a tube by which the voice is conveyed to it so as to excite vibration. The lime, or electric light, is reflected from this mirror through a convex lens, so as to render the rays parallel; these being received on a second lens at some distance, and again concentrated on a selenium receiver. This is the most important part of the apparatus. It consists of a slip of mica, 2¼ inches long and ¾ inch broad, round which is wound No. 40 copper wire in the form of a flat screw, with a pitch of $\frac{1}{18}$ of an inch. The ends are fixed through holes drilled in the mica. A second wire is then wound beside, but not touching, the first. A few grains of vitreous selenium are melted and dropped on the surface of the mica, being afterwards evenly spread by means of another slip of mica. The temperature should be just above the fusing-point of selenium. It is then allowed to cool. It is next annealed for several hours and allowed to cool very slowly. The terminals of this cell are joined up with a battery of eleven Leclanché elements and a pair of Bell telephones wound with finer wire than usual, in larger quantity than that required for ordinary telephonic communication. The voice is very fairly conveyed across a space of ten feet and into a neighbouring room by this simple form of apparatus.

The Thermic and Optical behaviour of Gases, under the influence of the electric discharge, has been further investigated by Wiedemann, and the results have been given at some length in the *Annalen*. He had before shown that when a mixture of two gases, of which one is a metallic vapour and the other nitrogen or hydrogen, is exposed to the electric discharge, the lines of the metallic vapour are seen in the spectrum, while those of the other gas remain invisible; so that the propagation of electricity is entirely due to the metallic vapour,—the discharge being entirely discontinuous. He had also shown that the temperature of the gas illuminating a Geissler's tube may be below 100°. It is thus proved that the usual theory referring the emission of light by gases to an increase of temperature up to the point of incandescence is no longer tenable, and requires fresh experimental examination. In this communication, he has thoroughly examined the thermic relations of the discharge of the induction machine under different conditions, and has discovered a peculiar behaviour of positive and negative electricity. Experiments follow to determine numerically the conditions under which the transformation of the band-spectrum into the line-spectrum occurs in hydrogen. The apparatus employed is described at length. It appears among other results that as pressure diminishes, the quantities of heat evolved diminish to a minimum and then rise again. With hydrogen the heating is generally less than with air. The number of discharges increases as the pressure diminishes, and then decreases again. The heating at the positive electrode diminishes continually and rapidly as the pressure decreases; that at the negative electrode at first decreases, and then increases rapidly.

Electric Conductivity of Carbon.—Dr. Werner Siemens has lately described to the Berlin Academy a new series of experiments on the electric conductivity of carbon, and the way it is affected by temperature. He finds that of gas retort carbon at 0 deg. = 0·0136 if mercury = 1—and the coefficient of increase of conductivity 0·000345 per degree Celsius. The artificial carbon rods produced by compression of carbon powder also show greater conducting power with increasing temperature, but the increase is not so great as in retort carbon. The electric conductivity of gas-carbon and its variability under pressure has been re-examined by MM. Naccari and Pagliani, and in such a way as to throw some doubt and some light on the theories advanced respecting the common microphone. Carbon prisms were inserted in a Wheatstone's bridge to determine their resistance. When subjected to great pressures the resistances of the rods of carbon showed scarcely any change. Hence it appears that the changes of conductivity which carbon exhibits in the microphone and in the carbon telephone under varying pressures, are due to mere changes in the external contact.

The similarity of Sulphur to Selenium in respect of its variable conductivity, is stated to be among the results of Prof. Graham Bell's recent researches, but only at temperatures below that at which it becomes dark and viscid.

Incandescent Electric Lights have been made successfully by Mr. Swan, of Newcastle-on-Tyne. The material used by him is a wire of dense and elastic carbon, made by a process which has not yet been disclosed. Each is about three inches long, about $\frac{1}{100}$ of an inch in diameter, and so light as to weigh only from $\frac{1}{15}$ to $\frac{1}{20}$ of a grain. Their durability is remarkable, as he states that lamps have been continuously lighted by them for over three months at a time, with an intermission of only three weeks. The light varies in intensity from 30 to 50 standard candles. Thirty-six such lamps were exhibited at his lecture, working from a dynamo-electric machine driven by a four horse-power engine. At a previous lecture, twenty lamps gave more light than the seventy-six gas jets usually supplying the room.

Fitzgerald's Magneto- and Dynamo-Electric Machines.—The improvements in magneto- and dynamo-electric machines, the invention of Mr. Desmond G. Fitzgerald, deserve careful attention, inasmuch as they show a decided advance in the right direction. The main idea of the inventor seems to have been to aim at perfecting the Gramme machine; and so, instead of rotating the ring between the poles of a magnet on the ordinary system, he wholly or partially surrounds the ring both longitudinally and transversely, thus increasing the effective inductive action. The ring is thus magnetized directly, and with the least possible loss, and the direction of the inducing magnetic polarity is in the circle constituted by the ring itself, as it should be.

Considerable modifications are made in the construction of the ring. Ordinarily, in winding a number of coils of wire upon a ring, more especially if it be of circular section, and if the number of turns of wire be the same in each layer, interstices are left between the coils. These interstices are filled by Mr. Fitzgerald with soft iron wedge-shaped blocks. These blocks can either be made with the ring, or separately, and slipped on, the ring being made in halves to receive them.

The Metric System.—There has lately been some agitation in the United States as to the advisability of rendering the Metric System compulsory for public use. It was legalized in May, 1866, and since then several societies have been organized to teach its principles.

Mr. Coleman Sellers, the well-known mechanical engineer of Philadelphia, argues in opposition that the inch is the resting-place or starting-point in the memory in all machine-shops where English is spoken, in Russia, generally in Germany, and possibly, though not always knowingly, in France. The inch is conveniently subdivided by a process of halving which provides the mechanic with all the sizes he needs, and which he finds ready to his hand in merchant goods. But Mr. Sellers goes further: he compares the inch with the millimetre in all the processes of the workshop, and shows how much superior is the inch or system of halving to that which the metric system compels us to adopt. For drawings made on the metric scale only seven sizes can be utilised—viz. full, half, one-fifth, one-tenth, one-twentieth, one-twenty-fifth, and one-fiftieth. With a good 2ft. rule, we can obtain twelve sizes—viz. full, half, third, quarter, sixth, eighth, and so on up to sixty-fourth, and to these can be easily added five of the others where the rule is also decimally divided, as good rules mostly are. There are thus seventeen sizes instead of seven for use with the inch-divided rule; but in drawing, the scales in most common use are one-half, one-fourth, and one-eighth, which in rapid drawing can be easily raised by taking diameters from one drawing and using them as radii in the other—a process impossible between one-half and 1-5 sizes. The true value of the extended series of scales is manifest to any one familiar with both, and what is remarkable is that draughtsmen brought up to metric scales take very kindly to the inch scale and prefer it. The great majority of sizes used in any machine, large or small, are less than one metre; and to avoid the errors likely to occur with decimals, the French or German mechanic uses the millimetre, writing 8mm. rather than ·008m., and the unit thus fixed is preserved until the larger parts are figured by perhaps many thousand millimetres, and these figures have to be squared and cubed with much multiplication, which would be saved by the use of the inch, the foot, and yard. With the use of the English measures, we complete the calculation sooner, because we are able to deal with the largest measures compatible with convenience; 'we can use the cubic inch, the cubic foot, or the cubic yard at our pleasure, just as the mechanic selects his tools in accordance with the extent of his work, and does not waste time driving at a railroad spike with a tack-hammer.' Mr. Sellers tells us he has tested the metric system in both drawing-office and machine-shop, and has been disappointed: 'an incorrectly figured drawing costs nothing on account of errors so long as it rests quietly in its drawer, but it costs fearfully when the error is discovered in the partially finished machine.' Messrs. Sellers have in one branch perfected an organization based on the metric system, and they have no intention of giving it up—precisely for the same reason that they will not change their older scales. As mechanics they recognize the fact that those who had the making of the metric scale began at the wrong end—the big end of the scale—the size of the world, and the units it has been cut into are found inconvenient in their shops, however convenient they may be for calculating in merchants' ledgers.—*English Mechanic.*

Researches of Mr. E. H. Hall.—As a new action of magnetism on a permanent electric current have already been described in this Summary, its direction was evidently a matter of fundamental importance. Prof. Rowland predicted that the direction would be reversed in paramagnetic iron from that found in diamagnetic gold, and experiment has verified the prediction. Mr. Hall finds, however, that nickel and platinum—both magnetic substances—resemble, not iron, but gold. The fact has to be taken into account in endeavouring to apply the newly-discovered action to explain the magnetic rotation of the plane of polarization in accordance with Maxwell's electromagnetic theory of light. He has, therefore, repeated Kerr's experiment on rotation by reflexion from the pole of a magnet, using nickel for the latter instead of iron. The disc was placed between the poles of an electromagnet. The action on the plane of polarization, though apparently much weaker than in iron, was unmistakably in the same direction. Prof. Hopkinson, in a note contributed to the *Philosophical Magazine*, shows that what Clerk-Maxwell calls the 'Rotatory co-efficient' completely expresses the important facts discovered by Mr. Hall. Of this co-efficient Maxwell says, 'We have reason to believe that it does not exist in any known substance. It should be found, if anywhere, in magnets which have a polarization in one direction, probably due to a rotational phenomenon in the substance.' The passage affords another remarkable instance of theoretical prediction, afterwards confirmed by experiment.

The Velocity of Sound in Gases has been very comprehensively compared by Herr Hilfer. He divides the methods into three groups:—

I. *Theoretical methods* (*a*) from wave-theory: results for air, V. = 280 m., with correction, 331·88 for 0°: (*b*) from the kinetic theory of gases, equal to $\frac{2}{3}$ or $\frac{8-2\pi}{\pi-2}$ of the mean value u of molecular velocity; result = 323·33 or 322·47; with correction on account of duration of collisions, 332 m.: (*c*) from a combination of the formulæ of wave-motion, and of the gas-theory; result = 331·94.

II. *Direct experimental methods*, in some of which, with length known, time is measured, either in open space or in tubes; in others, with time given, distance traversed: results, excluding the older experiments:—French Commission (1822) = 331·2; Moll and Van Beek (1823) = 332·25: correction by Schroeder van der Kolk = 332·77; Regnault (1868) = 330·6; Le Roux, = 330·66; Szathmari, by method of coincidences = 331·57.

III. *Indirect experimental methods*, from wave-length: (*a*) by measurement of the length of pipes; (*b*) by observation of dust-waves; (*c*) by means of interference tubes; (*d*) from coincident vibrations of two manometric flames: results, Wertheim = 331·33; Zoch (1866) = 332·65.—*Eng. Mechanic.*

The Dependence of Thermoelectric Currents on the Gases in contact with the Terminals having been asserted by Exner, Prof. C. A. Young has produced a test experiment on the point. An exhausted glass tube contained an iron wire with platinum terminals, which were again fastened to iron wires leading to a galvanometer. The tube was exhausted to one-millionth of an atmosphere. On laying the apparatus in sunlight, and alternately shading the internal or external junctions, an electromotive force could be produced which was found to be equal in every case. He considers this to negative Exner's statement.

Rotatory Magnetic Polarization in Gases forms the subject of a long paper in the *Annales de Chimie et de Physique*, by M. H. Becquerel. The principle has already been described. In the present paper a minute account is given of the apparatus employed, and the precautions adopted to insure accuracy. The apparatus consists of two distinct parts, (1) the optical, (2) the magnetic. The gas was contained in a tube 3·27 metres long, closed by parallel glass ends. Around, but not touching, this are six large coils, each containing 15 kilogrammes of wire, or about 90 kilogrammes in all, with a length of 1380 m., when joined in a continuous series. The current used was from 80 nitric acid batteries of large size, in two series of 40 each. Under so powerful a current, the conductors and the tube itself soon became warm, rising to a temperature of 40° Centig. or 102° Fahr. To estimate variations in the current from this cause, and also from changes in the battery, a sine-galvanometer was placed in a shunt from the main circuit, and a curve plotted from its indications. The quantity of gas operated on amounted to about 37 litres. It acted of itself as an air-thermometer by means of a pressure-tube. The amount of rotation being very small, only about 5′ of angular measure with an inverted current, it was found expedient to amplify it by the method of reflection used by Faraday and Foucault. Magnetic rotation is known to be proportional to the path traversed, in whatever direction it may pass. The source of light was lime, passed, in some instances, through coloured diaphragms. The polarizer was a large Nicol's prism, giving a beam over an inch in diameter. By means of two plane mirrors silvered in their middle part, the ray to be polarized was passed three, five, seven, or nine times along the length of the tube before being received on the analyzer. This consisted of a Foucault's prism mounted on a divided circle with a vernier reading to minutes of arc. Four double reflections, with nine passages of the ray through the tube, were generally employed. The current being passed in one direction the two images were brought to similar tint; and the current being then reversed, the analyzer was turned to similarity, and the angle read off, giving double the magnetic rotation for the substance experimented on. The necessary corrections for various causes of error were referred to bisulphide of carbon, the rotatory power of which is large. Besides temperature and magnetic intensity named above, there were, the displacement and want of homogeneousness in the source of light, rotations caused by the glasses, lenses, and mirrors of the apparatus,—all these are discussed at length and tabulated. A remarkable relation is shown between the index of refraction of a gas and its power of magnetic rotation. Oxygen, however, forms a notable exception.

ZOOLOGY.

A New Form of Cystic Worm.—M. A. Villot, who some time since described a peculiar cystic worm (*Staphylocystis*), parasitic upon *Glomeris limbatus*, has discovered another new form in the same myriopod, which he notices (*Comptes Rendus*, 6 December, 1880) under the name of *Urocystis prolifer*. It is a very minute creature, measuring only 0·09 millim. (less than $\frac{1}{250}$ inch) in length: and one remarkable circumstance about it is that it resides in the same host in two stages of its development—namely, as the true cystic worm in the visceral cavity of the *Glomeris;* and in the scolex state, encysted in the adipose tissue of the same animal. M. Villot describes the parasite as consisting of three distinct parts, which he calls head, body, and caudal vesicle. The head is oval, truncate in front, and furnished with four sucking discs, and with a long trunk. The latter is invaginated in the head, which in its turn is invaginated in the body, and this again in the caudal vesicle. The invagination of the trunk forms a funnel-like hollow at the apex of the head, and the inner wall of the latter is armed with a circlet of excessively minute hooks, $\frac{1}{2500}$ inch long.

The multiplication of the worm in the cystic stage is effected (as we understand the statements of the author) by budding at the posterior extremity of the caudal vesicle, and the buds are usually thrown off as soon as they are perfectly formed, so that the colony rarely consists of more than two individuals. The scolex formed in the bud, which remains during its final development attached to the parent worm by a thin pedicle, seems to resemble that of the parent in all respects; when detached it speedily throws off the enclosing vesicle, and proceeds to encyst itself in the adipose tissue of the host, still invaginated in the so-called 'body.' The further development of this worm is still unknown; it probably takes place in some Alpine bird or mammal, the cystic worms having been obtained from a *Glomeris* collected in the woods of the Grande Chartreuse.

The Discomedusæ.—Prof. Häckel has read before the Medical Society of Jena a memoir on the organization and classification of the Discomedusæ, a group which he defines as including all those Acraspeda which, in their youth pass through the well-known ontogenetic larval form of *Ephyra* (*Ephyrula*), as represented by the first free-swimming product of the division of the so-called *Hydra tuba.* These may be regarded in accordance with the 'biogenetic fundamental law,' as all phylogenetically derivable from an original common stock-form, resembling *Ephyra: Ephyræa.*—This common starting-form of all Discomedusæ possesses eight sense-organs (4 per-radial and 4 inter-radial), and alternating with these 8 adradial tentacles, and intercalated between the former and the latter 16 marginal lobes. The umbrella of all Discomedusæ is shallow and discoidal, and their sexual glands are developed by centripetal growth in the subumbral stomachal wall. The great number of new Discomedusæ which the author has had the opportunity of examining during the last few years have led him to form a new classification of the group. He distinguishes in it three sub-orders and ten families, characterized as follows:-

Sub-order 1.—CANNOSTOMÆ (Tubular-mouthed Medusæ): Mouth-tube simple, without buccal tentacles. Central mouth simple, square. Radial pouches, without an annular canal. Either 4 or 8 gonads (reproductive organs). Tentacles solid, usually short.

Families.—1. EPHYRIDÆ: Radial sacs broad, simple, without ramified distal canals, without an annular canal.—Subf. 1. *Palephyridæ,* with 8 sense-organs and 8 tentacles, with 4 horseshoe-shaped interradial gonads.—Genera, *Ephyra, Palephyra, Zonephyra.*—Subf. 2. *Nausithoidæ,* with 8 sense-organs and 8 tentacles, and 8 separated adradial gonads.—Genera, *Nausicaa, Nausithoë, Nauphanta:* Subf. 3. *Collaspidæ,* with from 16 to 32 sense-organs, and an equal number of tentacles, with 8 separated adradial gonads.—Genera, *Atolla*, *Collaspis*.

Family 2. LINERGIDÆ.—Radial sacs broad, with branched, cœcal distal canals, without annular canal.—Subf. 1. *Linanthidæ*, with 4 interradial, horseshoe-shaped gonads.—Genera, *Linantha*, *Linergis*: Subf. 2. *Linuchidæ*, with 8 separated adradial gonads.—Genera, *Liniscus*, *Linuche*.

Sub-order II.—SEMOSTOMÆ (Vane-mouthed Medusæ): Mouth-tube divided into 4 per-radial, folded buccal arms. Central mouth simple, circular: sometimes broad radial sacs, without annular canal; sometimes narrow radial canals, with an annular canal: always 4 gonads. Tentacles hollow, generally long.

Family 3. PELAGIDÆ.—Radial sacs broad, simple, without branched distal canals, without annular canal.—Genera, *Pelagia*, *Chrysaora*, *Dactylometra*.

Family 4. CYNANEIDÆ.—Radial pouches broad, with branched, cœcal distal canals, without annular canal. Subf. 1. *Medoridæ*, with 8 sense-organs,—Genera, *Procyanea*, *Medora*, *Stenoptycha*, *Desmonema*, *Cyanea*, *Drymonema*: Subf. 2. *Pateridæ*, with 16 sense-organs.—Genera, *Patera*, *Melusina*.

Family 5. FLOSCULIDÆ.—Radial canals narrow, simple, unbranched, with an annular canal.—Genera, *Floscula*, *Floresca*.

Family 6. ULMARIDÆ.—Radial canals narrow, all, or part of them, branched, with annular canal. Subf. 1. *Umbrosidæ*, with marginal tentacles. which are inserted on the margin of the umbrella between the marginal lobes,—Genera, *Ulmaris*, *Umbrosa*, *Undosa*. Subf. 2. *Sthenonidæ*, with subumbral tentacles, which are inserted upon the ventral side of the velar marginal lobes, at a distance from the margin of the umbrella,—Genera, *Sthenonia*, *Phacellophora*. Subf. 3. *Aurelidæ* with exumbral tentacles which are inserted upon the dorsal side of the velar marginal lobes, remote from the margin of the umbrella,—Genera, *Aurelia*, *Aurosa*.

Suborder III. RHIZOSTOMÆ (Root-mouthed Medusa).—Mouth-tube replaced by 8 adradial root-like buccal arms with numerous suctorial mouths. Central mouth obliterated. Radial canals narrow, always branched, with an annular canal. Gonads always 4 (never 8!) Tentacles absent.

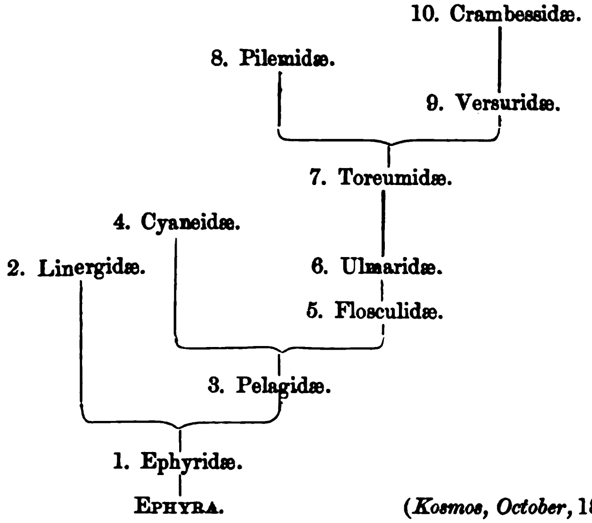
Family 7. TOREUMIDÆ.—Four subgenital cavities, separated, the branchial disc forming the floor of the stomach; suctorial fringes of the buccal arms only ventral, on their axial surface,—Genera, *Archirhiza*, *Cephea*, *Diplopilus*, *Polyrhiza*, *Cassiopea*, *Polyclonia*, *Toreuma*.

Family 8. PILEMIDÆ.—Four subgenital cavities, separated, branchial disc forming the floor of the stomach, suctorial fringes of the buccal arms dorsal and ventral, both on their axial and abaxial surfaces,—Genera, *Pilema*, *Eurhizostoma*, *Stylonectes*, *Toxoclytus*, *Phyllorhiza*, *Stomolophus*.

Family 9. VERSURIDÆ.—Four subgenital cavities, united to form a central portico; hence the floor of the stomach and the branchial disc are separated; suctorial fringes of the buccal arms only ventral, on their axial surface,—Genera, *Haplorhiza*, *Cotylorhiza*, *Octostyla*, *Crossostoma*, *Versura*.

Family 10. CRAMBESSIDÆ.—Four subgenital cavities, united to form a *central portico*, hence the floor of the stomach and the branchial disc are separated; suctorial fringes of the buccal arms dorsal and ventral, both on the axial and abaxial surfaces,—Genera, *Leptobrachia*, *Thysanostoma*, *Mastigias*, *Himantostoma*, *Rhacopilus*, *Catostylus*, *Crambessa.*

The comparative anatomy and ontogeny of the Discomedusæ enable us approximately to recognize very clearly the phylogeny of the ten families. The common stem-group of the whole order is formed by the Cannostome family Ephyridæ, with the stem-genus *Ephyra* (*Ephyræa*). From this, first of all, two divergent families were developed:—the Linergidæ and the Pelagidæ. The latter form the stem-group of the Semostomæ, and split into the two families Cyaneidæ and Flosculidæ, from which last proceeded the Ulmaridæ, and from these again the Toreumidæ, the stem-group of all the Rhizostomæ. The two families, Pilemidæ and Versuridæ, are probably divergent branches of the Toreumidæ, while the Crambessidæ have probably originated from the Versuridæ (but perhaps also from the Pilemidæ). This phylogenetic hypothesis is displayed by Prof. Häckel in the following genealogical tree:—



(*Kosmos, October*, 1880.)

Classification of the Pennatulida.—In his report on the Pennatulida collected during the voyage of the *Challenger*, Prof. Kölliker proposes the following new classification of those curious Polyps:

Order PENNATULIDA.

I. Rhachis with a bilateral arrangement of the polyps.
  A. Rhachis elongated, cylindrical.
    AA. With pinnules or leaves . . . . Sect. I. PENNATULEÆ.
      * Pinnules well developed . . . . Subsect. 1. PENNIFORMES.
        a. Zooids situated on the pinnules . Fam. 1. Pterocididæ.
          Genera, *Pteroeides*, Herkl., *Godefroyia*, Köll.
          Sarcophyllum, Köll.

b. Zooids on the ventral and lateral
sides of the rhachis . . . . Fam. 2. Pennatulidæ.
Genera, *Pennatula*, Lam., *Leioptilum*, Verr.
Ptilosarcus, Gray, *Halisceptrum*, Herkl.
bb. Pinnules small . . . . Subsect. 2. VIRGULARIEÆ.
a. Pinnules without a calcareous plate Fam. 1. Virgularidæ.
Genera, *Virgularia*, Lam., *Scytalium*, Herkl.
Pavonaria, Köll.
b. Pinnules with a calcareous
plate . . . . Fam. 2. Stylatulidæ.
Genera *Stylatula*, Verr. *Dubenia*, Kor. and Dan.
Acanthoptilum, Köll.
BB. Rhachis without pinnules, polyps
sessile . . . . Sect. II. SPICATÆ.
a. Polyps on both sides of the rhachis
in distinct rows . . . . . . Subsect. 1. FUNICULINEÆ.
aa. Polyps with cells.
α. No ventral zooids . . . . Fam. 1. Funiculinidæ.
Genera, *Funiculina*, Lam., *Halipteris*, Köll.
β. With ventral zooids . . . Fam. 2. Stachyptilidæ.
Genus, *Stachyptilum*, Köll.
b. Polyps on both sides of the
rhachis in a single series, or
in distinct rows . . . . Subsect. 2. JUNCIFORMES.
aa. Polyps without cells.
α. Polyps large.
αα. Rhachis elongated,
cylindrical . . . Fam. 1. Kophobelemnonidæ.
Genera *Kophobelemnon*, Asb., *Sclerobelemnon*,
Köll., *Bathyptilum*, Köll.
ββ. Rhachis short . . Fam. 2. Umbellulidæ.
Genus *Umbellula*, Lam.
β. Polyps small . . . . Fam. 3. Protocaulidæ.
Genera, *Protocaulon*, Köll.,
Cladiscus, Kor. and Dan.
bb. Polyps with cells . . . Fam. 4. Protoptilidæ.
Genera, *Protoptilum*, Köll., *Lygomorpha*,
Kor. and Dan., *Microptilum*, *Leptoptilum*,
Trichoptilum and *Scleroptilum*, Köll.
B. Rhachis expanded in the form of a leaf. Sect. II. RENILLEÆ.
Fam. 1. Renillidæ.
Genus, *Renilla*, Lam.
II. Rhachis with a radiating arrangement of
the polyps . . . . Sect. III. VERETILLEÆ.
A. Calcareous bodies long . . . . Fam. 1. Cavernularidæ.
Genera, *Cavernularia*, Val. *Stylobelemnon*, Köll.
AA. Calcareous bodies short . . . . . Fam. 2. Lituaridæ.
Genera, *Lituaria*, Val., *Veretillum*, Cuv.
Policella, Gray, *Clavella*, Gray.

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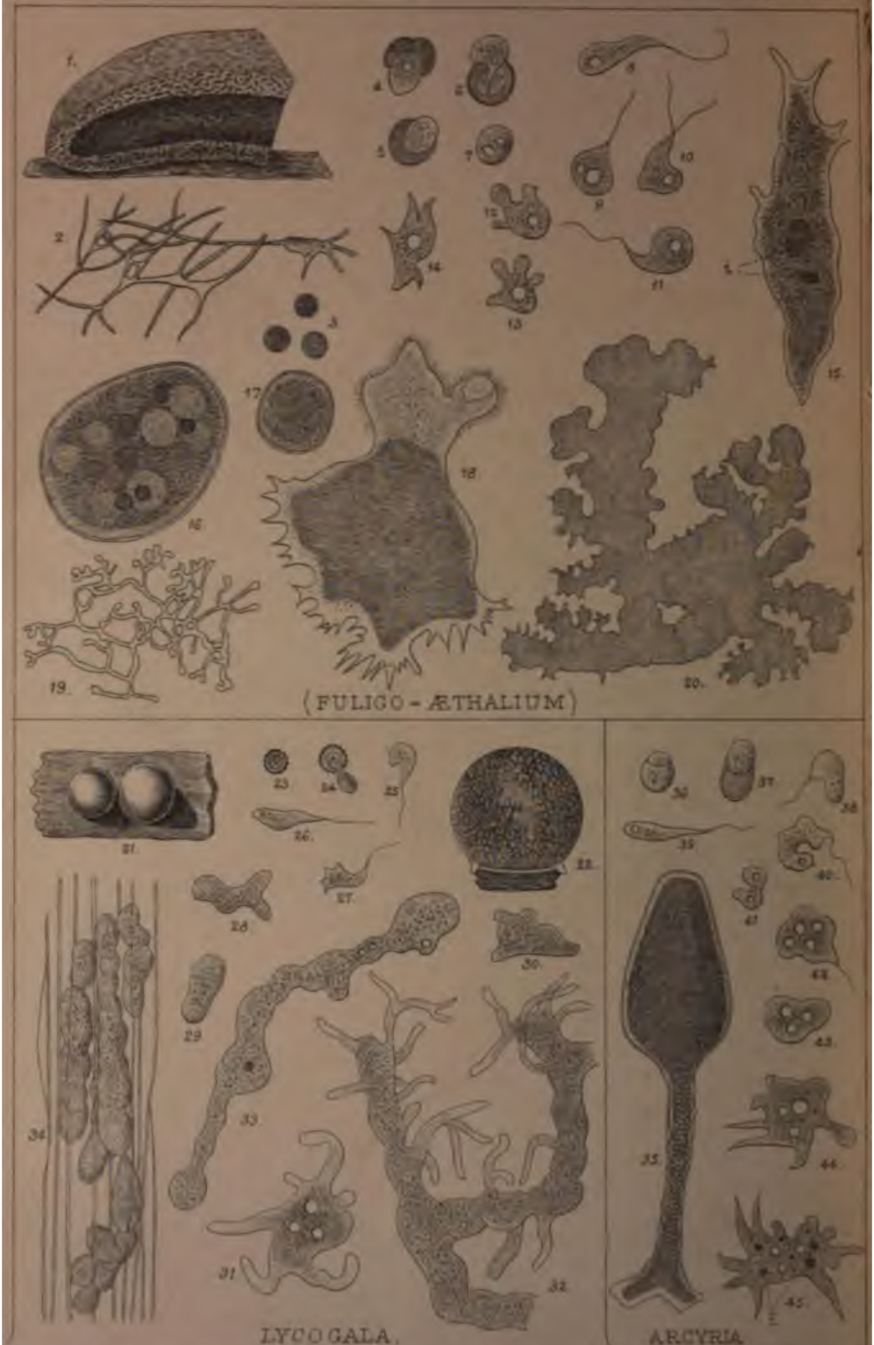
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ARCYRIA.

MYCETOZOA.

THE MYXOMYCETES OR MYCETOZOA; ANIMALS OR PLANTS?

By W. SAVILLE KENT, F.L.S., F.Z.S., F.R.M.S.

[Plates III. and IV.]

ALONG the lower confines of the organic world diverse group-forms are to be encountered, of which it is hard to predicate whether they rightly appertain to the animal or to the vegetable series. Prior to that deeper insight into the mysteries of Nature that, thanks chiefly to the improvements made in the compound microscope, has fallen to the lot of the present generation, organisms of even large appreciable dimensions—such as Sponges, Corals, and Zoophytes—furnished subjects of contention between Zoologists and Botanists. Before the rapid advance of modern science, however, the lists for controversy have been gradually growing more and more confined, further progress at the same ratio threatening ere long to place the biologist in the position of the classic hero, who wept for the want of other worlds to conquer. Already, the cordon drawn around the once extensive tourney-ground includes only the lower groups pertaining to Cryptogamic Botany and to that subdivision of the animal kingdom most usually defined by the title of the Protozoa, but which might, with equal consistency, be designated the department of Cryptogamic Zoology. All of these agree with one another, and at the same time differ from the more highly organized groups of Phanerogamic plants and Metazoic animals respectively in the obscure and comparatively rudimentary character of their reproductive phenomena.

In recognition of the extreme difficulty that attends the precise definition of an arbitrary boundary line that shall, to the satisfaction of both Botanists and Zoologists, separate the subjects of their respective studies, Biologists have from time to time proposed the institution of an intermediate kingdom or neutral territory for the reception of all those doubtful organic forms which with more or less justice have been shifted from one side to the other of the barrier-line in accordance with the strength of the evidence adduced. Thus, Mons. Bory de St. Vincent originally instituted for the inclusion of such debatable types his *Le Règne Psychodiaire;* and thus Prof. Ernst Häckel, scantily acknowledging, perhaps, Bory's lead, has quite recently substituted in its place, his so-called kingdom of the 'Protista,' which, in accordance with its founder's views, includes the following divisions:—

Kingdom *Protista*, Häckel.

		Generic type.
Class 1.	Monera	*Protomyxa.*
2.	Lobosa	*Amœba.*
3.	Flagellata	*Euglena.*
4.	Catallacta	*Magosphæra.*
5.	Labyrinthulæ	*Labyrinthula.*
6.	Diatomeæ	*Navicula.*
7.	Myxomycetes	*Æthalium.*
8.	Rhizopoda	*Gromia.*

As already pointed out by the writer in *A Manual of the Infusoria*, Vol. i. p. 44 *et seq.*, October, 1880, the recognition of such a proposed neutral territory or kingdom by no means lessens, but simply enhances, the pre-existing difficulty. For in place of the simple boundary-line that had formerly to be defined between animals and plants it necessitates the definition of two such lines—the one between the Protista and the lower animals, and the other between that group and the lower plants. Furthermore, as demonstrated by the writer in this treatise, there is scarcely one out of the eight class divisions included in this newly proposed kingdom that cannot be relegated with absolute certainty to one or the other of the two older primary divisions. Several of these groups, again, are most artificially constructed. The class Monera is well-nigh obsolete. Formerly proposed by Häckel for the reception chiefly of the Foraminifera and certain Protozoa, including *Bathybius* (?), in which the presence of a nucleus or endoplast had not been detected, a few obscure amœbiform organisms alone remain to sustain its titular reputation. The Lobosa, as a class separate from the ordinary Rhizopoda, cannot be consistently recognized; while the so-called Catallacta, including the single genus *Magosphæra*, may be appropriately likened to a colonial form of such a multiflagellate Infusorium as *Lophomonas.* Taken as a whole, six out of the eight classes enumerated in the foregoing list conform in all essential points with that formula of organization distinctive of the lowest or Protozoic section of the animal kingdom. Of the two residual groups, that of the Diatomeæ as assuredly belongs to the vegetable series; one only being finally left, of which it may be said that opinions are substantially divided as to their animal or vegetable affinities. It is with this single section, No. 7, or that of the Myxomycetes, that this article purposes to deal.

The Myxomycetes, Myxogastres, or Mycetozoa, as they have been variously designated, have up to a very recent date remained undisturbed within the precincts of the vegetable kingdom, being accepted on all hands as constituting a subordinate, though somewhat abnormal group of the Gasteromycetous Fungi. The diagnosis of the order, as given in M. J. Berkeley's *Introduction to Cryptogamic Botany*, 1857, and reproduced in other English text-books of Mycology, runs as follows:—

'*Whole plant at first gelatinous. Mycelium often vein-like, forming reticulated or anastomosing strata, but sometimes diffuse, giving rise to sessile or stipitate, free or confluent peridia, consisting of one or more membranes, enclosing, when mature, a dry mass of threads or plates, and spores; at length often bursting. Threads of various structure, sometimes containing one or more spirals.*'

Mr. Berkeley further proceeds to say (l. c. p. 336),—' This is, perhaps, one of the most remarkable groups of Fungi, and at present one on which we have least information. In their early stage they consist of a pulpy or cream-like mass, collected in distinct globules, or creeping over its matrix in the form of branched anastomosing veins. In this stage the tissues are so delicate that they exhibit no structure, and if hardened with alcohol give no further information. From their great fragility when fully grown, and the free dispersion of their dust-like spores, they are with difficulty preserved in an herbarium. But no Fungi afford more elegance of form or singularity of structure according to the nature of the peridium, the flocci, and the disposition of the spores, which are their three main elements. The beauty of form of their peridia is often combined with exquisite colouring, which is sometimes brilliantly metallic, exhibiting tints of steel, gold, copper, or silver, most nearly resembling in this respect very thin membranes met with in the animal kingdom, such as those of the eggs of certain moths. One form, *Æthalium septicum*, is the pest of hothouses, while a species of *Licea*, *L. perreptans*, sometimes increases with such rapidity in cucumber and melon-frames, as to seriously interfere with the culture of these fruits. One marked peculiarity of the Myxomycetes is represented by their indifference as to the matrix upon which they grow. The same species may occur on plants of the most distant natural affinities, and on other matrices. One species was observed by Schweinitz to be developed on iron which had been heated in a forge only a few hours previously. Mr. McIver found one on a leaden tank, while Mr. James Sowerby discovered another on cinders in the outer gallery of St. Paul's Cathedral. Like Algæ they appear to derive their nutriment from the surrounding medium, and not from the matrix to which they are attached.'

The data embodied in the foregoing and earlier accounts of the Myxomycetes were held to demonstrate their rightful position to be among the Gasteromycetous Fungi, their apparent nearest allies being the Trichogasters or Puffballs, *Lycoperdon, Borista*, &c., from which, however, they essentially differed in the production of their peridia, or sporangia, from a structureless, pulpy mass instead of from a distinct cellular hymenium. (Illustrations of the fungus-like, matured peridia or spore-receptacles of various typical representatives of the Myxomycetes, natural size and magnified, will be found in the accompanying Plates III., figs. 1, 21, and 35, and IV., figs. 1, 24, and 30 to 32.) So far, the developmental phenomena of these singular organisms—which among both animals and plants are now universally recognized as furnishing the true key to their natural position and affinities—had remained undiscovered, or involved in the greatest obscurity. About the year 1859, however, Dr. A. De Bary, the accomplished Professor of Botany at Freiberg University, applying himself to the solution of this moot question, arrived at some totally unexpected results. The spores on careful cultivation were found to give rise, not to jointed cellular hyphæ, or mycelia, as obtains among all ordinary Fungi, but to flagellate monadiform germs possessing active locomotive faculties, a spheroidal nucleus or endoplast, one or more contractile vacuoles, and the faculty of ingesting solid food-substances. After a short interval these germs, retracting their flagella, assumed an amœboid repent phase and coalescing freely with their neighbours, built up the so-called gelatinous, or pulpy masses, out of which the sporangia, or peridia, were developed. With relation to the phenomena exhibited by the Myxomycetes during their active vegetative life, De Bary arrived at the conclusion that they could not be consistently retained as vegetable organisms, but were referable to the lower animal series, or Protozoic sub-kingdom, and might be more conveniently designated the 'Mycetozoa.'

In the year 1862, the main results arrived at by De Bary were confirmed by L. Cienkowski,* who now for the first time definitely associated with the so-called pulpy mass, derived through the coalescence of the monadiform germs, the title of the 'plasmodium.' This plasmodium, taking the form of either a colossal Amœba, or other Rhizopod, in addition to possessing locomotive faculties and the capacity of ingesting solid food, he further showed to exhibit, in its more extended, ramified condition, a distinct circulation or cyclosis of its internal granular elements. Embodying the results of Cienkowski's investigations with those of his own earlier and more recent researches, De Bary published, in the year 1864, his more extensive account of the Mycetozoa,* which up to the present date is accepted as representing the most complete record extant of the life phenomena of these remarkable organisms. While still included among the Fungi, perhaps for convenience sake, by systematic botanists, their exceedingly anomalous plan of structure and development has in most instances been fully recognized. No more fitting illustration of the estimate accorded to them by this class of biologists is perhaps to be found than the general account of the group included in Julius Sachs' *Textbook of Botany*,† herewith reproduced *in extenso* :—

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* *Zur Entwickelungs-geschichte der Myxomyceten, in Pringsheims Jahrbücher für wissenschaftliche Botanik.* Berlin, 1862.

'The Myxomycetes include a numerous group of organisms which in many respects differ widely from all other vegetable structures, but in the mode of formation of their spores stand nearest to the Fungi, on which account we may treat them as a supplement to that class. The Myxomycetes are remarkable in no ordinary degree from the fact that during the period of their vegetation and assimilation of food they do not form cells or tissues. The protoplasm, which in all other plants is also the general motive power of the phenomena of life, remains in them during the whole of this period perfectly free, collects into considerable masses, and assumes various shapes from the internal force residing in it without becoming divided into small portions which surround themselves with cell-walls, or become cells. It is only when the protoplasm passes into a condition of rest in consequence of being surrounded by unfavourable conditions, or when it concludes its period of vegetation by the formation of the reproductive organs—its internal and external movements ceasing at the same time—that it breaks up into small portions which surround themselves with cell-walls, and which even then never form a tissue in the proper sense of the term. The Myxomycetes live upon decaying and rotting vegetable substances. While endowed with motion, they either creep over the surface of the substratum or live in hollows and pores in its interior, but for the purpose of reproduction they always come to the surface. When entering on the reproductive condition, the entire protoplasmic substance, plasmodium, becomes transformed into sporangia or larger receptacles. In *Æthalium septicum*, the so-called "flowers of tan," this spore-receptacle is represented by a cake-like mass, not unfrequently measuring a foot in length and breadth and over an inch in thickness. The inside of the cake is dark-grey, easily pulverized, and penetrated by yellow veins consisting of tubes interwoven in all directions. The skin, or cortex, consists of densely interwoven, irregular bundles of tubes connected in a peculiar manner, and containing an immense number of calcareous grains as well as a yellow pigment. *Æthalium*, in its plasmodium condition, is able to creep away from the tan upon which it was originally growing, and, climbing up neighbouring plants to the height of several feet, accumulates upon their leaves. The monadiform germs developed from the spores are, under unfavourable circumstances, transformed into microcysts; when dry they remain in this state for months, reverting again to the mobile form when placed in water. The young plasmodia are also capable, under like conditions, of forming cysts out of which they again creep on the return of warm, moist weather. The more matured plasmodia may likewise enter upon a temporary state of rest,—sclerotium. First drawing in its arms or outlying ramifications, it next assumes a sieve-like contour or becomes resolved into a mass of irregular nodules, and the whole substance breaks up into a large number of round or polyhedral cells. When placed in water, the cell-walls again become absorbed, and the sclerotium reverts to the condition of a mobile plasmodium. Finally, the plasmodium having attained its full growth, a fine membrane, or pellicle, is formed over its surface and the interlacing capillitium and spores within, the lime contained within the plasmodium being deposited in the form of granules on the capillitium or wall of the sporangium. The passage to this reproductive phase is accomplished with great rapidity,—two hours only being quite sufficient, in the case of *Æthalium*, to convert a soft mobile plasmodium into the motionless, cake-like sporangium. The water previously contained in the plasmodium is partly expelled in the fluid state, while the residue speedily evaporates.'

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* *Die Mycetozoen ein Beitrag zur Kenntniss der niedersten Organismen.* Leipzig, 1864.

† English edition, translated by A. W. Bennett and W. T. Dyer. London. 1875.

Upon the data included in the foregoing epitomization of the structure and life history of the Myxomycetes, and more especially with regard to those that relate to their earlier locomotive and ingestive faculties, it is not to be wondered at that many biologists have come to look upon their association with vegetable organisms as no longer tenable, and to decide that their nearest allies are to be sought for among the animal series. Such an opinion was freely expressed by Prof. Allman in his

Presidential address, chiefly relating to lower organisms, delivered to the meeting of the British Association for the year 1879. Others, taking an intermediate view of the question, have contented themselves with allotting this group a half-way position in the organic chain, Prof. Häckel, as previously notified, incorporating the Myxomycetes in his newly-established kingdom of the Protista, while Prof. Huxley* remarks of their flagelliferous monadiform germs that 'they are embryonic forms of organisms which appear to be as much animals as plants; inasmuch as in one condition they take in solid nutriment, and in another have the special morphological, if not physiological, peculiarities of plants.'

Being greatly impressed in favour of the evidence adduced in support of their animal affinities, the present writer has, in a general outline of the sub-kingdom Protozoa, included in Part I. of his *Manual of the Infusoria*, thought fit to accept the Myxomycetes, or Mycetozoa, as veritable Protozoa, indicating at the same time the very numerous points in which their structural and developmental phenomena tally with those of the more typical representatives of that zoological series. In this manner it was shown that the initial term or flagelliferous unit developed from the spores of these so-called Fungi—possessing a nucleus, contractile vesicle and capacity to incept solid food particles — is in noways distinguishable from an ordinary representative of the genus Monas, as defined by the writer at p. 232 of the *Manual* quoted. The succeeding or 'plasmodium' phase of these organisms, likened by its describers to a colossal Amœba, is similarly correlated by the writer (l.c. pp. 42 and 192) with *Labyrinthula*, and with the amœbiform masses produced through the coalescence of a greater or less number of primary flagellate zooids, out of which the reproductive gemmules of a sponge-body are built up.† The spore-receptacles, or sporangia, are finally interpreted as corresponding on an extended scale with the ordinary encapsuled or encysted conditions of the typical

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* *Anatomy of Invertebrated Animals*, p. 44, ed. 1877.

† An additional type, whose adult structure resembles in a remarkable manner the 'plasmodium' condition of the Mycetozoa, is afforded by the *Biomyxa vagans*, as figured and described by Prof. Leidy in his recently published *Fresh-water Rhizopods of North America*, Washington, 1879. This organism, which inhabits the Sphagnum swamps of New Jersey and Pennsylvania, and may be compared to a shell-less *Gromia*, protrudes lobate extensions, or anastomosing pseudopodia, in every direction, which exhibit a distinct granule circulation, while a greater or less number of contractile vesicles are developed, both upon the surface of the body and along the pseudopodial extensions. The likeness cited as subsisting between these correlated organisms is indeed so great, that Prof. Leidy has some doubts as to whether it represents an immature Mycetozoon or an independent Rhizopod. In one example figured, the central protoplasmic mass is filled with ingested *Closteria*.

Protozoa, and also with the hybernating encystments or so-called 'gemmules,' or 'statoblasts' of *Spongilla*, and other Sponge types. Further affinities with the Sponges — these organisms being accepted as Flagellate Protozoa—were held to be manifested in connexion with the fine net-work of anastomosing fibres or 'capillitium,' singularly resembling the horny rete of the keratose Sponges, which is usually developed within the sporangia of the Myxomycetes, and to which are frequently added crystalline or nodular deposits of lime that may be consistently compared with the calcareous or siliceous, spiculiferous elements of ordinary Sponge forms.

While it was expected that mycologists, pure and simple, would be somewhat loth to relinquish the interesting little group of Myxomycetes into the hands of the zoologists, it was anticipated that the protest against their advocated transfer would have been raised upon a more substantial basis than that lodged by Dr. M. C. Cooke in his Journal of Cryptogamic Botany, 'Grevillea,' for December last. Instead of applying himself to a concise and lucid exposition of those points, which, to his mind, establish, as he expresses it, the 'truly vegetable nature' of the Myxomycetes, Dr. Cooke confines his criticism of the views advocated by the writer to an unsupported contradiction of the facts accepted as indicative of their animal affinities, accompanied by what must be objected to as a direct misrepresentation of the arguments used in the practical application of these facts to the question raised. In the first place, it is affirmed that De Bary has entirely abandoned his former views respecting the animal affinities of the Myxomycetes. Can Dr. Cooke quote any work or paper in which a renunciation of the facts and opinions expressed in his treatise, *Die Mycetozoen*, published in the year 1864, is recorded? This record again being, not as his critic ingeniously affirms, written 'in a hurry and repented at leisure,' but representing the result of many years' careful investigation, backed by the confirmation of all essential facts at the hands of an independent authority. The editor of 'Grevillea' next politely suggests that, in attempting to correlate the Myxomycetes with the Protozoa, the present writer has 'gone out of the way to meddle with a subject that he does not understand,' that he has no practical acquaintance with the organisms of which he treats, and no knowledge of the later important Polish and other works upon the Myxomycetes, which do not support their animal affinities. Finally, Mr. Saville Kent is accredited with an attempt 'to squeeze the Myxomycetes into the animal kingdom by stealth;' and to have done this in defiance of axioms he has elsewhere adopted, for the distinction of the ordinary infusorial types from lower plants, including, more particularly, their capacity to ingest solid food. That the Myxomycetes are endued with a similar ingestive faculty, Dr. M. C. Cooke practically denies.

To the foregoing heavy bill of indictment it is incumbent upon the accused to make some brief response. To the one count, that of having based his arguments in support of the animal nature of the disputed group mainly, if not entirely, on the evidence adduced by De Bary and Cienkowski without having then a practical knowledge of the organisms or their more recent literature, the writer must to some extent plead guilty. Such admission must, however, be qualified by the fact of his having a short while since made himself familiar with both the structure and developmental phenomena of various ordinary fungi under able guidance at the South Kensington Biological Laboratory, so that he was not altogether meddling with an unknown subject in pronouncing an opinion upon the claims of the Myxomycetes for association with these Cryptogams. Neither respecting more recent literature can the writer acknowledge himself to have been entirely in the dark. As a subscriber to that work, he possessed, and had referred for further information, to Dr. M. C. Cooke's *Handbook to British Fungi*, Vols. I. and II., published in the year 1871, and in which he confidently anticipated finding a masterly, *ex-cathedrâ* summary of all that was known concerning the structure and vital phenomena of the Myxomycetan order, with a special reference to the investigations of Continental mycologists. The distinguished compiler of the *British Handbook* had, no doubt, worked out the problem for himself, and had important affirmative or negative evidence to submit. Alas, for such hopes! Trace of original investigation there was none, while the latest literature of the subject with which the editor displayed familiarity was Berkeley's *Outline of an Introduction to Cryptogamic Botany*, quoted over leaf, and written fourteen years before (1857). His diagnoses and more general descriptions of the characters of not only the Myxomycetes, but also of the Hymenomycetes, Gasteromycetes, Coniomycetes, and Hyphomycetes, with those of their leading secondary subdivisions are admittedly copied word for word from that source. The results of the writer's well-intentioned efforts in pursuit of knowledge, so far therefore as they related to the *Handbook of the British Fungi*, have to be registered a blank. The serial that enshrines Dr. Cooke's indignant repudiation of the writer's furtive attempts to rob mycologists of one of their most interesting orders kindled hope anew. Though silent as the Sphinx concerning the titles of the newer important works, that if consulted would have convinced the writer of the error of his ways, the editor of 'Grevillea' produces on the cover of his journal a list of his voluminous contributions to Cryptogamic literature, including one bearing the title of 'the Myxomycetes of Great Britain. London, 1877.' Here, at length, was a 'Daniel come to judgment;' here, doubtless, were to be found revealed developmental facts and features undreamt of in the philosophy of De Bary and Cienkowski, and by which the writer was to find that the views he advocated respecting the animal nature of these organisms were utterly demolished. The book in question, however, as advertised in 'Grevillea,' hardly fulfils the promise of its title. In place of an original treatise, representing the outcome of many years' original research on the part of Dr. Cooke, it proved to be a mutilated transcript only of a 'monograph of the Mycetozoa,' published by Rostafinski, in Polish, in the year 1875. As the author naïvely admits on the title-page, 'the characters of all the orders, families, and genera, with descriptions of the British species and original analytical tables,' are reproduced word for word from the Continental work; and since 'the Myxomycetes of Great Britain' consists exclusively of these translated characters, with two or three pages of editorial introduction, its claim to recognition as an independent treatise as announced in 'Grevillea,' is somewhat doubtful. As a translation, limited only to the diagnoses of the British representatives of the group, it furthermore does but imperfect justice to the more comprehensive system embodied in Rostafinski's Monograph; and it is therefore satisfactory to know that a complete translation of this work from the Polish into the German language is shortly announced.

Thus much for the external features of the 'Myxomycetes of Great Britain,' but what of the internal ones? Instead of producing, as the writer anticipated, a complete refutation of De Bary's and Cienkowski's observations, Rostafinski not only embodies in his diagnosis of the group the characters of the several developmental stages made known by these two authorities, but also in many instances reproduces their figures in conjunction with his own, and even adopts De Bary's title, 'Mycetozoa,' in preference to that of Myxomycetes, for the distinction of the group. It needs indeed but to reproduce Dr. Cooke's translation of Rostafinski's diagnosis of the order, as given below, to demonstrate this point:—

'MYCETOZOA. De Bary, 1861; Rostafinski, 1875.

'When young, naked, mobile, in consequence of which the masses of plasmodium have a changing form. These masses at the time of fructification, sometimes dividing themselves into single parts, are transformed into motionless fruits. Fruit either irregular in form (*plasmodiocarp*) or regular (*sporangium*). Sporangia, through fusion and union, produce, now and then, compound fruits (*Æthalium*). Æthalium usually of considerable dimensions, of regular or irregular form, naked, or covered with a common coat (cortex). Spores produced within the fruit through free-cell formation, or on the surface through division. The contents of the spores at the time of germination give rise to either at first a naked zoospore provided with a nucleus, a cramped (contractile) vacuole, and long cilia, or to an amœboid. These zoospores, or amœbæ, floating together in masses, give rise to mobile plasmodia.'—*Rstfki. Mon.*, p. 83.

The points conceded in the foregoing diagnosis, viz., the derivation of the sporangia from mobile plasmodia, which are themselves built up through the coalescence of a greater or less number of spore-derived amœboid or flagelliferous units, which are provided with contractile vesicles, and, it should be added, the faculty of ingesting solid food, furnish all that the writer requires for the establishment of their animal nature and affinities. Rostafinski's systematic monograph, at the same time, deals almost exclusively with the histology and specific distinctions of the sporangia and their contained elements, no data or drawings of their developmental phases being included, beyond such as are evidently derived second-hand from De Bary and Cienkowski. The editor of 'Grevillea' ignoring the facts adduced by these authorities, denies that the Myxomycetes subsist on solid food matter, and has possibly a revelation of his own to disclose. Can it be that he gives adhesion to a novel interpretation of the development of the group placed on record by a Mr. George Massie in the pages of *Science Gossip* for January 1881, and in which the Mycetozoon *Spumaria alba* is represented as producing spores, which give rise to jointed hyphæ, after the manner of the typical Fungi? A submission of the drawings of these germinating spores to a mycological expert, resulted, as was anticipated, in the verdict that they had nothing whatever to do with the species to which they were accredited, but represented the adventitious spores of a species of *Penicillium*, most probably *P. crustaceum*. Mr. Massie treats the account given by De Bary and Cienkowski of the spores giving exit to motile monadiform or amoeba-like germs as an idle tale, unsupported by correlation with any recognized specific form, and which must vanish into thin air before the weighty proofs adduced through his own original investigation of *Spumaria alba*. The spores of *Fuligo varians* (*Æthalium septicum*) are also referred to by this writer as giving origin to branching threads, though, unfortunately, the further development of it 'was not observed.' Other nameless species are likewise reported by Mr. Massie to have exhibited a similar plan of germination, while not in a single instance out of a number of types experimented upon were mobile cells observed to originate directly from a spore.

That Mr. Massie is totally unacquainted with the original records of De Bary and Cienkowski is evident from the fact that in making a quotation from the general account of the Ontogeny of the Mycetozoa, as elicited by De Bary, delivered by Prof. Allman to the British Association meeting in the year 1869, he remarks: 'It is much to be regretted that the Professor should not mention the species presenting such unusual and interesting phenomena.' Had Mr. Massie consulted the two authorities cited, he would have discovered that the developmental phenomena referred to were traced in connexion with no less than twelve well-known species, a list of which is herewith given :—

Didymium Libertianum, De Bary = *Chondrioderma difforme*, Rtfki.
Stemonitis obtusata, Fr. = *Comatricha Friesiana*, Rtfki.
Stemonitis fusca, Roth.
Æthalium septicum, Fr. = *Fuligo varians*, Somm.
Enerthenema papillata, Bourn.
Arcyria punicea, Pers.
Trichia varia, Pers.
Lycogala epidendron, Fr.
Didymium serpula, Fr.
Didymium leucopus, Fr. = *Physarum leucopus*, Rtfki.
Physarum album, Fr. = *Condrioderma difforme*, Rtfki.
Licea pannorum, Wallroth.

In the two plates accompanying this article, the writer has further reproduced from the voluminous drawings of MM. De Bary and Cienkowski, their most characteristic illustrations of the developmental phases of some half-a-dozen of the above-named species; in all of which it is clearly shown that the spores give birth to monadiform germs, out of which, through further development and coalescence, the repent amœbiform plasmodia, and subsequently the fungus-like sporangia, are constructed.

Finally, since the Editor of 'Grevillea' has determined to repudiate this testimony, he declares that in order to establish the animal nature of the Myxomycetes, it is requisite to produce evidence of a more substantial kind than the mere citation of De Bary and Cienkowski, suggesting in a previous paragraph that the present writer has no practical acquaintance with the organisms under discussion, but has simply 'based his theory upon the figures he has observed in illustrated books.' Unfortunately for this intended overwhelming argument, it happens that even previous to the publication of his views in favour of their zoological affinities, the writer was by no means unacquainted with representatives of this interesting group. Examples of *Craterium pyriforme* (named by Dr. Cooke) and *Badhamia inaurata*, collected some time since and lately examined, assisted him to arrive at the opinion submitted. This examination, admittedly, was restricted to the matured Sporangia and their component elements, the developmental phenomena being recorded, as duly acknowledged, on the strength only of the two Continental authorities. More recently, however, recognizing that greater satisfaction would be derived from a personal investigation of these developmental data, a variety of species have been carefully cultivated with the most substantial results. In addition to the two species above named, the writer has been supplied by Mr. Thomas Brittain, a well-known mycologist of the Manchester district, with authentic examples of *Lycogala epidendron*, *Stemonitis fusca*, *Diachæa elegans*, and *Physarum tussilaginis*. Spores of all were sown in distilled water on ordinary slides, covered with thin glass, and kept, when not under direct examination, in a moist chamber. These were now examined from day to day and hour by hour. In some instances, where the spores had been preserved for too long an interval, germination failed, but in other cases, notably *Badhamia inaurata*, *Stemonitis fusca*, and *Physarum tussilaginis*, an interval of from three or four days to a week has sufficed for the rewaking of their latent vitality and the liberation of the contained germs. These germs in every instance agreed substantially with the figures and descriptions given by De Bary and Cienkowski,—the one form, *Stemonitis fusca*, illustrating a type examined by the first-named writer, while the two others represent species of which the developmental phases have not been previously described.

The phenomena exhibited, as observed by the present writer, while in all cases identical, may be preferentially recorded of *Physarum tussilaginis*, illustrated by the accompanying Pl. IV., figs. 30 to 55. In this species the spores being of large relative size,—1 – 2000″ to 1 – 1500″, those of the other forms averaging but little more than one half these dimensions,—are admirably adapted for cultivation. The power chiefly employed in their more minute examination was a $\frac{1}{16}$th inch objective by Gundlach, with a magnification of from 600 to 1200 diameters; a lower power, $\frac{1}{4}$ inch, sufficing for taking a more general numerical survey. So soon as within seven hours after wetting the spores, or indeed directly following their deposition on the slide, an examination revealed the companionship of innumerable *Bacteria*, at present quiescent, with a more or less abundant sprinkling of spores other than those of *Physarum*, and of considerably smaller size. The presence of these adventitious elements immediately, and not unnecessarily, suggested the desirability of precaution in the registration of subsequent events. The spores specially sown were found, under high magnification, to consist of an outer wall of considerable thickness, finely echinulate externally, and exhibiting, by transmitted light, a dark amber or chitinous coloration. The protoplasmic contents rarely entirely filled the outer shell, but remained separated from it by a greater or less number of angular interstices. A central spheroidal nucleus, with a contained nucleolus, one or more large refringent corpuscles, and numerous smaller granules, represented the sum-total of the recognizable internal elements. By the end of the second day active life had already dawned upon the scene. Bacteria were swiftly propelling themselves to and fro in all directions; one or two biflagellate monads, *Heteromitæ*, whose development was subsequently traced from certain of the smaller spores above mentioned, glided slowly along, dragging their posterior flagella, 'gubernacula,' cablewise behind them; then presently a turn of the stage adjustment brought the observer face to face with a germinating spore, having a slender thread-like hypha. Robinson Crusoe's feelings, when stumbling upon the naked footprint on the sand, frequently imagined, were momentarily realized. Were De Bary and Cienkowski in the wrong? Had they mistaken some of these *Heteromitæ*, or other intruding monads, for Myxomycetan germs? and did this interesting little group after all develope after the manner of a common Fungus? A little more patience, and the spore from which the hypha emanated was discovered to be entirely distinct from those of the *Physarum*, and the barometer of our hopes was once more in the ascendant. Sparsely scattered amongst the spores of the Myxomycetan were presently observed, isolated hyaline protoplasmic spheres having the same diameter and structure as the contents of the spore-cases, just described. In a little while the exit of one of these hyaline spheres from the echinulate spore-cases was witnessed, and the relationship between the two substantially established.

By the termination of the third day, these protoplasmic spheres had much increased in number, some of them exhibiting feeble amœboid movements. An additional factor had, however, now appeared upon the scene in the form of a vermicular monadiform organism (Pl. IV., figs. 49 and 50), having a length of 1–1250″ to 1–1000″, and which progressed somewhat clumsily through the water revolving on its longitudinal axis. A spheroidal nucleus, with its enclosed nucleolus, was observable towards the anterior extremity, and a single rhythmically contracting vesicle at the opposite region of the body. The derivation of these monadiform beings, from the extruded protoplasmic spheres, was immediately suspected, and the correctness of this inference soon substantiated. Selecting an isolated and recently-extruded sphere, it was carefully watched; and within a space of two hours the entire transformation was gradually accomplished

For a considerable interval the newly released germ confined its signs of vitality to a feeble expansion and contraction of its peripheral margin, and to the rhythmical pulsations of its contractile vesicle, which, as well as the spheroidal endoplast, was clearly discernible. As time progressed, alterations in contour were more strongly manifested, though without the germ moving away from the scene of its birth. At length an altogether elongate amœboid, or vermiform aspect predominated, the nucleus or endoplast being shifted to one extremity and the contractile vesicle occupying the other. Then all at once, a flickering at the end containing the nucleus indicated the development of a flagellate appendage, which in a few seconds became distinctly visible. The vibratile motion of this organ soon caused the body to oscillate and presently lifted it from its hitherto prone position. It now remained adherent only by its posterior extremity, and, in a few more seconds, was launched into the surrounding water a free-swimming, elongate monad. The several successive phases just described will be found illustrated in Pl. IV. by the figures numbered consecutively 43 to 48. During the next few days, similar monadiform germs were developed abundantly from the spores in all parts of the field, and the next step in their ontogeny fully certified. It was found in fact that the free-swimming condition of the germs was but of brief duration, and subservient, apparently, only to their local distribution. Within a day or two, sooner or later, the monadiform beings once more betook themselves to a repent mode of existence, the flagella being for a while retained, communicating to them a remarkable likeness to the repent flagelliferous animalcules, for which F. E. Schulze has proposed the generic title of *Mastigamœba.* The flagella being completely withdrawn, the organisms were now undistinguishable from ordinary *Amœbæ*, and continued to creep about the field by broad, ovate expansions of their periphery, after the manner of those Rhizopods.

An important point yet remained to be solved. De Bary and Cienkowski had declared that during both their monadiform and subsequent amœboid phases, the Myxomycetes ingested and subsisted on solid food matter, figures as given by them in illustration of such nutritive faculties being reproduced in Pl. III., figs. 15, 16 and 45, and Pl. IV., figs. 12, 13 and 28. This evidence has been regarded by some writers as extremely doubtful, while by others it has been categorically denied. A simple experiment, however, soon demonstrated that these two authorities were again completely in the right. Examples, more especially of the repent amœboid units, had been previously observed, whose bodies contained vacuoles more or less completely filled with ingested *Bacteria*, which, being produced in numbers prior to the hatching out of the *Physarum* germs, provided for the Mycetozoa an abundant and ready set feast. The common test of adding pulverized carmine to the water, of such value in [illegible] faculties of ordinary Infusoria was [illegible] by both the rotatory m- [illegible] neither possessing a distinct [illegible] particles chiefly towards the [illegible] latter indifferently at any [illegible] the case of *Bacteria* the smaller [illegible] after ingestion were usually [illegible] vacuoles of the endoplasmic [illegible] the same molecular movements [illegible] The larger particles [illegible] distributed as more or less distinctly [illegible] next few days, and indeed up to the [illegible] ten days or a fortnight [illegible] these amoeboid organisms [illegible] in size, many of them [illegible] dimensions, and may be said to [illegible] the succeeding chapter in [illegible] through coalescence of the [illegible] plasmodia, out of [illegible] are finally evolved.

[illegible] personal investigation [illegible] phenomena of the [illegible] the writer as affording [illegible] previously expressed [illegible] whatever to be [illegible] Protozoa [illegible]

[illegible] — the so-called [illegible] it is an [illegible] that build up the [illegible] and physiologically identical reproductive structure. While thus the life-cycle of an ordinary Monad may be declared to be an elaborated epitomization only of what, when reduced to its simplest expression, takes place with the Myxogasters, or as they may be preferably designated the Mycetozoa, this last-named group can undoubtedly claim bonds of affinity with other more complex Protozoa. Thus, as previously intimated, the horny rete or capillitium mostly, but not always, developed within the sporangium of the Mycetozoa, singularly resembles the horny network or skeletal elements of the keratose sponges; while the calcareous concretions also frequently, but not invariably, developed in intimate connexion with the capillitium and wall of the sporangium, may be similarly compared with the mineral concretions or spicula of the sponges. As certain sponges occur that possess neither a horny rete nor spicula, so Mycetozoa are also to be found having no mineral concretions, and in which the capillitium is either absent or altogether rudimentary, demonstrating alike in either instance the non-essentiality of these several elements. A case in point illustrative of the resemblance that subsists between sponge spicules and the mineral concretions of the so-called Fungi is afforded by the species of *Physarum*, whose developmental phenomena have just been recounted, and in which, as shown at Pl. IV., fig. 35, the minute stellate calcareous bodies scattered over the outer wall of the sporangium, are directly comparable with the minute stellate spicula characteristic of the Sponge group distinguished by the title of the Tethyidæ.* In yet another direction the two groups of the Mycetozoa and Spongida may be co-ordinated. The sporangia or spore-receptacles of the first-named class, representing the quiescent state entered upon as the closing act of vegetative life, while morphologically comparable with the encysted phases of the ordinary Flagellate Infusoria, may, in virtue of their essentially compound character, be more correctly identified with the spicule-invested, compound, hibernating encystments or statoblasts (Carter), into which many sponge forms, including *Spongilla*, become resolved on the termination of the season's growth, and out of which are again liberated the flagelliferous elements that build up anew compound sponge-stocks.

In conclusion. With those mycologists to whom every spore-capsule is necessarily a Fungus, and whose vision is sealed to every organism beyond their special line of research, the group of the Myxomycetes or Mycetozoa, will doubtless to the end of time be Fungi still. Embryological, developmental, and even structural data, are with these taxonomists of no account; a receptacle containing spores, never mind whence derived, and no matter what it produces, constitutes with them the *ne plus ultra* of what they are pleased to term a Fungus. With the intelligent biologist, however, who approaches the question, familiar with the fundamental structural, and developmental phenomena of other lower organic groups, and who is qualified accordingly to strike a just balance in accordance with the evidence, it is herewith predicated that the days in which these organisms shall be accounted Fungi, or even vegetable types, are already numbered. Every successive stage in their life-history, from their first exit from the spore until their final resolution into similar reproductive bodies, may be consistently correlated with those of the typical Protozoa, and with them alone. With the Fungi, on the other hand, their likeness, as manifested only in the matured spore-receptacle, is altogether superficial and illusory. In the pages of 'Grevillea' the writer has been accused of an attempt 'to squeeze the Myxomycetes into the animal kingdom by stealth.' The present article constitutes in itself, perhaps, the fullest refutation of this charge. The stronger and more intense the light from all sides concentrated upon the question at issue the better. Above all things, moreover, let the light be reflected on the subject by means of the mirrors and condensers of our compound microscopes. Let each for himself work out the simple morphological and developmental data that must ultimately decide the point. But before all things let the subject be approached by those possessing so sufficient a practical acquaintance with all cognate organisms as shall forewarn and forearm them against the innumerable pitfalls that will otherwise encompass them on every side.

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* It has been maintained by some advocates of the vegetable nature of the Myxomycetes, that these spicule-like structures differ in no way from the crystalline secretions of many plant-tissues known as 'rhaphides.' The unsoundness of such an interpretation is however made obvious in connexion with the fact that plant rhaphides are essentially *intra*-cellular secretions, while the spicular elements of both the Sponges and Mycetozoa are as strictly *extra*-cellular developments.

EXPLANATION OF PLATE III.

The letters n. and c. v. have the same meaning throughout, signifying, respectively, the nucleus or endoplast, and the contractile vesicle.

Figs. 1–20. *Æthalium septicum*, Fries. *Fuligo varians*, Somm. (*after De Bary*).

Fig. 1. Portion of margin of ripe sporangium showing crust-like outer wall and internal spore mass, natural size.

Fig. 2. Fragment of internal, horny network, or 'capillitium,' × 390.

Fig. 3. Three isolated spores, × 390.

Figs. 4–7. Amœbiform germs being liberated through the rupture of the spore-wall; that at 7 entirely free, × 390.

Figs. 8–11. Successive flagelliferous or monadiform phases of the same germs.

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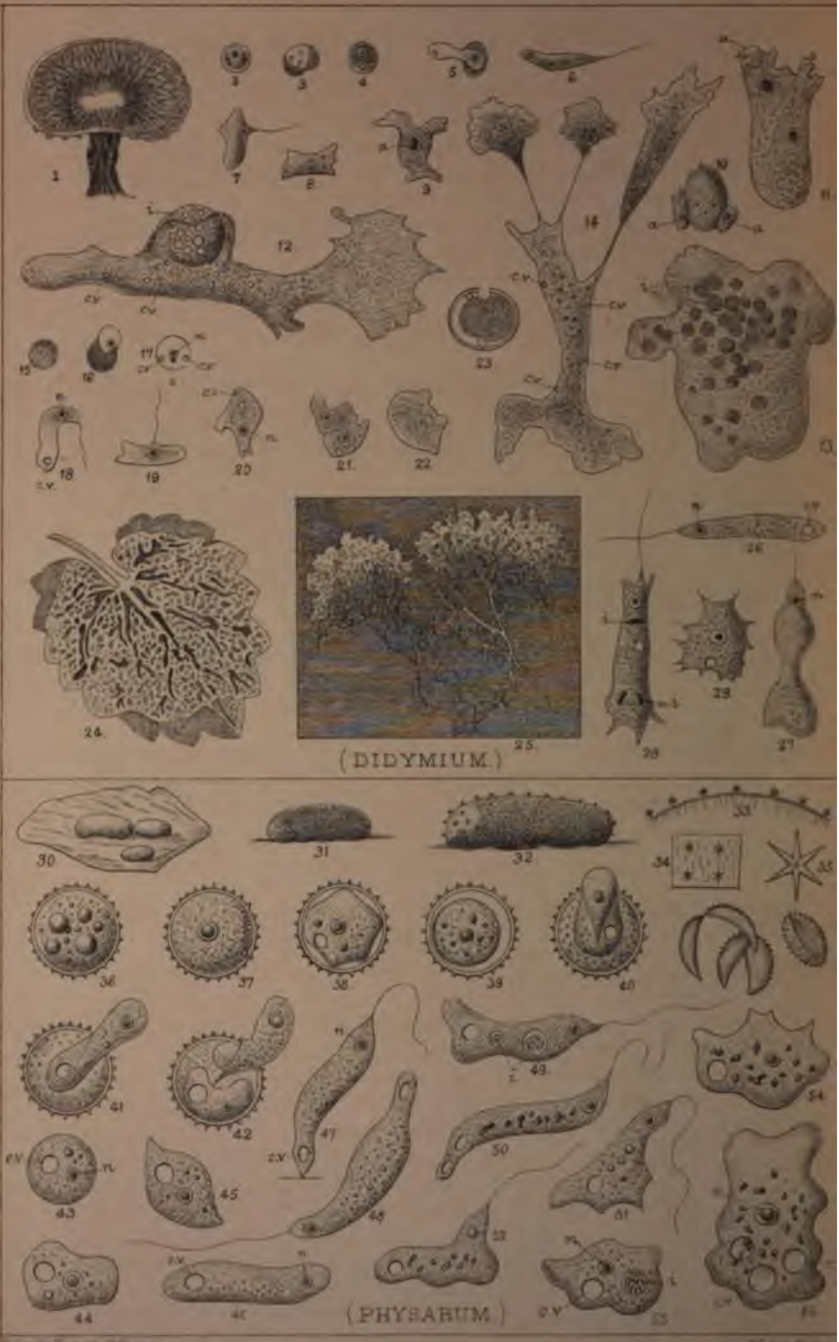
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(PHYSARUM.)

MYCETOZOA.

FIGS. 12–14. More advanced germs which have again assumed the repent amœboid state, × 390.

FIG. 15. A small repent 'plasmodium,' produced through the further development and continuance of a number of the preceding amœboid units; at *i*, ingested food substances, × 390.

FIGS. 16, 17. Encysted plasmodia; the one at 16 containing numerous ingested *Æthalium* spores, × 200.

FIG. 18. Young repent plasmodium, with fine, hair-like pseudopodia developed posteriorly, × 390.

FIG. 19. A ramifying plasmodium extended on a glass slide; natural size.

FIG. 20. Fragment of the same plasmodium, × 45.

Figs. 21–34. *Lycogala epidendron*, Fries. (*after De Bary*).

FIG. 21. Two matured sporangia attached to tan-wood, natural size.

FIG. 22. A mature sporangium in perpendicular section, showing disposition of capillitium, × 10.

FIGS. 23–30. Successive developmental phases from the spore through the flagelliferous stage, until at 29 and 30 the condition of young repent plasmodia is arrived at, × 390.

FIGS. 31–34. More matured plasmodia, that at 32 exposed to view through making a section of tan-wood, × 390.

Fig. 35. *Arcyria cinerea*, Fries.
Figs. 36–45. *Arcyria Punicea*, Pers. (*after De Bary*).

FIG. 35. Matured sporangium, × 30.

FIGS. 36–45. Developmental phases from the germination of the spores through a monadiform condition to the repent plasmodium state; the example at 45 with *i*, ingested food particles, × 390.

EXPLANATION OF PLATE IV.

Figs. 1–14. *Didymium Libertianum*, De Bary (*after De Bary.* 2–14, *after Cienkowski*).

FIG. 1. Matured sporangium in longitudinal section, showing capillitium, × 25.

FIGS. 2–9. Developmental phases from the germination of the spore to the condition of small repent plasmodia, × 350.

FIGS. 10 and 11. Small repent plasmodia increasing their dimensions through coalescence with the more minute amœbiform units *a a a*, × 350.

FIGS. 12 to 14. More matured plasmodia, that at 12 in the act of engulphing a large food corpuscle, *i*, and that at 13 filled with similarly ingested corpuscles, the attenuatedly extended plasmodium at 14 with four laterally developed contractile vesicles, × 350.

FIGS. 15 to 22. Similar developmental phases of *Didymium* (*Physarum*) *album*: at 21 the amœboid units uniting to produce the young plasmodium, fig. 22, × 350.

FIG. 23. Spore containing two germs. (After De Bary.)

Figs. 24–29. *Didymium*, Fries. (*After Cienkowski.*)

FIG. 24. Matured sporangium developed in a reticulate form over a living leaf of ground ivy (*Glechoma hederacea*), natural size.

FIG. 25. Portion of matured erect branching plasmodium. Nat. size.

FIGS. 26–29. Monadiform and amœboid germs, that at 28 with *i i*, ingested food particles, × 550.

Figs. 30–55. *Physarum tussilaginis*, B. and Br. (From the writer's original drawings.)

FIG. 30. Three matured sporangia adherent to a leaf of common coltsfoot. (*Tussilago farfara*), × 5.

FIG. 31. Isolated sporangium, × 10.

FIG. 32. A small sporangium in lateral view; towards the extremity *a*, the spores having escaped, have left bare the thin membranous wall, with its externally scattered calcareous spicula, × 30.

FIG. 33. Margin of membranous wall of sporangium, with on the upper surface equidistantly dispersed spicula, and on the under one delicate branching capillitium threads, × 100.

FIG. 34. Fragment of sporangial membrane with scattered spicula as seen in superficial view, × 100.

FIG. 35. An isolated hexradiate-stellate spiculum from the sporangial membrane, × 400.

FIGS. 36–39. Germinating spores showing different stages of development, × 800.

FIGS. 40–42. Spores with their walls ruptured, giving exit to amœbiform germs; at 42 an abnormal example containing two germs, × 800.

FIGS. 43–48. Successive phases of development of a single extruded germ to a free-swimming monad, as described at page 111, × 800.

FIGS. 49, 50. Two free-swimming monads, in the former one the vacuoles at *i*, contain exceedingly minute injected carmine particles; the example at 50 with larger, and scattered ingested granules of the same pigment, × 800.

FIGS. 51, 52. Monads that have entered upon a repent amœbiform existence, the flagella as yet being retained; the example at 52 with ingested carmine particles, × 800.

FIGS. 53–55. Repent amœbiform zooids, or young plasmodia, representing ulterior developmental phases of the preceding free-swimming monads; the examples 54–55, with numerous ingested carmine particles, × 800.

THE PERMANENCE OF CONTINENTS.

By J. STARKIE GARDNER, F.G.S.

'IT is not too much to say that every spot which is now dry land has been sea at some former period, and every part of the space now covered by the deepest ocean has been land.' This sentence occurs in the latest edition of Lyell's *Principles of Geology*, still perhaps the most authoritative text-book on the subject, and the view it expresses has been generally received as an article of faith by geologists until within a few years, or even months ago.

Lately a change of view has taken place, and now many distinguished men hold the completely opposite opinion that oceans have been permanent from the remotest times, and that continents are, and have ever been, fixed lands, subjected to ceaseless modifications of form. Among the most conspicuous partisans of the new theory are Sir Wyville Thomson, Prof. Geikie, and Mr. Wallace; and the latter especially seems to have collected together and presented in his fascinating book, *Island Life*, every kind of evidence that tends to support it. Nothing appears to have escaped him, yet the whole when summed up must seem to every geologist to fall far short of proof. Still, although the evidence upon which the theory is based is as yet wholly insufficient, it by no means follows that the theory itself is improbable.

The chief evidence upon which the *Permanence of Continents* at present rests, is purely geological. It is argued that the whole of the sedimentary rocks are littoral deposits, or those of inland seas; and if this can be maintained, the theory would, almost as a matter of course, be accepted. Mr. Wallace, therefore, endeavours by every means to prove it.

Chief among deposits hitherto supposed to be oceanic, is the Chalk; and to the discussion of this formation, accordingly, almost a whole chapter is devoted. Mr. Wallace expresses the belief that, far from the Chalk sea representing a wide ocean with a few scattered islands comparable to some parts of the Pacific, 'it formed as truly a portion of the great northern continent as it does now.'

The evidence, which he has to set aside, in favour of the Chalk being a truly oceanic deposit, is extremely weighty however, and by no means easily disposed of. Its vast extent—stretching from Sweden to Bordeaux, and from Ireland to China—and its freedom everywhere from impurities derived from the degradation of land, are greatly in favour of its oceanic origin. The areas that are known to have been denuded, and the enormous deposits of flint-shingles which characterize the Eocenes from their base upward to the most recent gravels, show how colossal this denudation has been.

The Chalk that has escaped seems but the fragment of a mass which once passed under the Atlantic, for even the Scilly Isles are strewn with flint, and the last remains of it in Devonshire and the north of Ireland are as pure as elsewhere, and show no signs whatever in the Chalk itself, towards its western boundaries, of the proximity of shores. This vast deposit abounds with *Globigerina*, of species identical with those of the modern Atlantic mud, and with coccoliths and discoliths. Representative siliceous Sponges are abundant in both, and the recent chalk-mud has yielded a large number of the group *Porifera vitrea*, which find their nearest representatives among the *Ventriculites* of the White Chalk. The Echinoderms of the deeper parts of the Atlantic basin are very characteristic, and yield an assemblage of forms which represent in a remarkable degree the corresponding group in the White Chalk. Species of the genus *Cidaris* are numerous; some remarkable flexible forms of the Diademidæ seem to approach the *Echinothuria*;* *Rhizocrinus* is closely allied to the chalk *Bourgueticrinus*, while even among fish the genus *Beryx*, so abundant in the Chalk, has been found by Dr. Carpenter, and the fresh light that the publication of the deep-sea fish of the *Challenger* Expedition is likely to throw on the subject will be looked forward to with much interest.

Prof. Duncan,† when investigating Corals, became impressed with the remarkable persistence of character and absence of variability in those of the deep-sea fauna. 'The dredging in 1095 fathoms off the coast of Portugal, which yielded *Pentacrinus Wyville-Thomsoni*, Jeffreys, produced many corals; and the series presented an eminently Cretaceous facies. The genus *Bathycyathus*, whose species, *Sowerbyi*, is so well known in the Upper Greensand, was represented there by numerous specimens of a species closely allied to that form.'

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* Sir Wyville Thomson, *Nature*, vol. iii. p. 297.

† *Quart. Jour. Geol. Soc.* xxvii. p. 437.

A new species of *Caryophyllia*, allied by its structural peculiarities to *C. Bowerbanki* of the Gault, and a species identical with the well-known *Caryophyllia cylindracea*, Reuss, sp., were discovered at the same time. The homotaxis of part of the Coral fauna of the Atlantic and that of the Cretaceous ocean, Prof. Duncan considers to be very remarkable.

Against this well-nigh irresistible evidence in favour of the oceanic origin of Chalk, Mr. Wallace states that no specimen of Globigerina ooze yet examined agrees, even approximately, with Chalk in chemical composition. The differences between the few analyses that have been published, are chiefly in the relative quantities of carbonate of lime, silica, alumina, and oxide of iron. It is by no means apparent that Sir W. Thomson's sample is the nearest analogous deposit to Chalk that could be found in the beds of the Atlantic or Pacific; but supposing it to be so, the great changes in chemical composition to which Chalk has been subjected since its consolidation, are entirely overlooked in comparing the analyses.* Chalk is, and probably always has been since its upheaval, constantly saturated with percolating rain-water, which enters as soft water charged with carbonic acid, and comes out in springs of hard water charged with carbonate of lime; and this alone in the course of ages would carry away the more soluble constituents such as iron, alumina, and magnesia. An even more important change is due to the removal by segregation of its silica into the form of flint. This, doubtless, took place when the silica was in a colloid state, and seems to have been arrested, whilst the Chalk was consolidating, wherever harder and softer layers alternate. Its once viscid, almost fluid, state is shown by the manner in which it has penetrated the minutest pores of Echinoderms before destroying the shell; and it seems probable from the way in which it has replaced carbonate of lime,† that it had not parted with its

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* The analyses relied upon in support of this are by Sir W. Thomson, of Globigerina ooze, viz.:—

Carbonate of Lime	43·93	to	79·17	per cent.
Carbonate of Magnesia	1·40	to	2·58	"
Alumina and Oxide of Iron	6·00?	to	32·98	"
Silica	4·60	to	11·33	"
Supposed Volcanic Dust	4·60	to	8·33	"

And of Chalk, by David Forbes:—

	Grey Chalk, Folkestone.	White Chalk, Shoreham.
Carbonate of Lime	94·09	98·40
Carbonate of Magnesia	0·31	0·08
Alumina and Phosphoric Acid	a trace	0·42
Chloride of Sodium	1·29	—
Insoluble débris	3·61	1·10

† All the carbonate-of-lime shells are replaced in the Blackdown deposits by silica.

organic acids. That it did not assume the solid state until at least after the partial consolidation of the Chalk is obvious, through the filling in of fissures at right angles to the bedding, which could not have existed when it formed the surface sediment of the ocean bottom. In comparing the White Chalk analysis with that of the ooze, therefore, we must bear in mind that, as already pointed out by Mr. Sorby, Mr. Sollas, and Dr. Wallich, a portion of flint must be added equal to that which has been separated away. In a similar manner, iron has been removed and segregated together, to be crystallized principally into globular balls with a radiating structure.*

The shells composed of carbonate of lime, such as those of Gastropods,† Cephalopods, and Dimyaria, seem also to have been dissolved away, perhaps by the rain-water which falls upon the Chalk, saturates it, and passes through it by capillary action unceasingly. Another evidence of change is shown in the crystalline condition of shells composed of phosphate of lime, such as the Aviculidæ, the Branchiopoda, the Echinodermata, &c.

It is surprising to find that no allusion whatever is made to this range of facts by Mr. Wallace; and those of his readers who are unacquainted with them, are left unaware that Chalk has undergone such great changes in its composition since it was the bed of the sea, as to deprive the unqualified statement that the analyses of Chalk and Globigerina ooze 'do not even approximately agree,' of any scientific value.

These facts further tend to show, as indeed is obvious from a comparison of the faunas, that the similarity in the analysis of the Oahu chalk and the White Chalk, upon which so much stress is laid, is purely superficial.‡ In spite of the fact

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* It assumes very beautiful forms in the Grey Chalk, and has occasionally completely replaced Sponges. The iron is frequently ochreous in the White Chalk.

† Gastropods are found as casts in the Grey Chalk, slightly coated with iron, and occasionally traces are met in the Lower White Chalk in the same condition. Higher than this even the most indistinct outlines of the larger forms, such as *Pleurotomaria*, are rare. I have seen but one trace of shell on any spiral Gastropod, and this on a fragment of *Funis* from the White Chalk near Norwich. Small thin fragments adhered to the cast, and the circumstance is remarkable as *Funis* almost alone of the Gastropods preserves its shell in the Cambridge Greensand. The shells of Cephalopods seem to possess a slightly greater resisting power, and their casts are, as a rule, more distinct.

‡ Analysis of Oahu chalk:—

Carbonate of Lime	92·800
Carbonate of Magnesia	2·385
Alumina	0·250
Oxide of Iron	0·543
Silica	0·750
Phosphoric Acid and Fluorine	2·113
Water and loss	1·148

Geology of the U. S. Exploring Expedition, p. 150.

that 'this chalk consists simply of comminuted corals and shells of the reef,' and is, when examined microscopically, 'found to be destitute of the minute organisms abounding in the chalk of England,' Mr. Wallace states that in several growing reefs a similar formation of modern chalk, undistinguishable from the ancient, has been observed.

Mr. Wallace thus assumes that the Chalk is derived from excessively fine mud produced by the decomposition and denudation of coral reefs; but this view appears to me to be untenable. Mr. Murray expressly states that no *Globigerinæ* were found in any of the enclosed seas of the Pacific which possess this chalky bottom; and to account for *Globigerina* in the Chalk it has to be supposed that the Chalk sea was open to the Gulf Stream, *i.e.* the Atlantic. Further, to provide the necessary conditions we are obliged to suppose this vast sea to have been bordered with islands and coral reefs, and that no large rivers flowed into it, and yet absolutely no traces of these coral reefs remain, while an inland sea could hardly have existed in proximity to a great permanent continent without some rivers draining into it. A curious piece of reasoning is that in the Maestricht and Faxoe chalks 'we have a clear indication of the source whence the white calcareous mud was derived which forms the basis of the chalk.' If these local and far newer deposits are seen to be highly coralline and the Chalk is not seen to be so, we have rather a clear indication that they were not deposited under the same conditions. The presence of *Mosasaurus* in the Maestricht beds, and the far newer aspect of its fauna, show that it must have belonged to an altogether different period, probably the one represented in America by a great so-called Cretaceous series containing a mixture of Cretaceous and Tertiary mollusca, dicotyledonous plants, and *Mosasaurus*. From every point of view, in fact, the inference that the vast Cretaceous deposits are analogous to small local deposits of coral mud in the Pacific does not appear to be the true one.

With regard to the probable depth of the ocean which deposited the Chalk, the evidence brought together by Mr. Wallace is less unsatisfactory. Mr. J. Murray, for instance, sees the greatest resemblance to it in mud from depths of less than 1000 fathoms; and Dr. Gwyn Jeffreys finds that all the Mollusca of the Chalk are comparatively shallow-water forms. We must bear in mind, however, that the characteristically deep-sea families and genera, such as *Bulla* and the Solenoconchia, *Leda*, *Neæra*, and *Verticordia*, would have long since been dissolved away if present; while great and highly characteristic cretaceous genera, such as *Inoceramus* and *Hippurites*, are wholly extinct, and nothing therefore can be safely predicated concerning their habits.

In the Grey Chalk near Folkestone dark impressions of nearly all the deep-sea Mollusca enumerated above are abundant; and the Gault and a part of the Lower Greensand are full of their shells in perfect preservation. Their absence in England at least, from the Chalk, seems very clearly due rather to subsequent destruction than to their never having been present. Of the Chalk genera that are preserved, *Pecten*, *Amussium*, *Lima*, *Spondylus*, *Anomia*, and the Brachiopoda are represented by Dr. Gwyn Jeffreys as having been dredged at from 1450 to 1750 fathoms and upwards. As for the abundance of Ammonites showing, as Dr. S. P. Woodward once supposed, the water to have been as shallow as thirty fathoms, Mr. Wallace himself would be the first to repudiate such mere supposition, were it urged against the theory he seeks to establish. Were *Nautilus* and *Spirula* shallow-water forms they would long since have been captured abundantly. The still existing shells of the Chalk itself are so few that little weight can be attached to them as an indication of depth, but in the lower Cretaceous deposits Mollusca abound, as already stated, and in perfect preservation; and their facies, taken with the complete absence of shallow-water forms, implies, Dr. Gwyn Jeffreys believes, a depth of sea in the Gault period of somewhere about 1000 fathoms. Mr. Sorby, from quite other considerations, believed the Gault to be an altered red clay, similar in all essential respects to the red clay now forming at the ocean-bottom. There seems thus to be abundant evidence, endorsed by our greatest authorities, that at least some of the Cretaceous deposits were deep-sea, while there is a total absence in them of anything necessarily indicating the proximity of land.* With regard to the Chalk itself, however, the facts are still somewhat contradictory, for it far overlaps the Gault and Grey Chalk in Devonshire, and rests upon greensand; yet although it thins out to the west it remains a perfectly pure rock, without any apparent evidence of the upper part of the formation having gradually shallowed as the sea-bed became upheaved.

The immensity of the gap, seldom adequately realized, between the true Cretaceous and the next overlying beds, implies an interval sufficient to have permitted the grandest changes in the distribution of land and water, and the gulf of the Atlantic, which stretched over the greater part of Europe, to become elevated; and, after enormous denudation, to be converted into land.

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* No American or European so-called Cretaceous land-flora can be proved to be as old as our White Chalk. The few vegetable remains found in marine Cretaceous rocks are not incompatible with the deposits having taken place at a distance from shore.

But even altogether apart from what is to be learned from the Cretaceous rocks, it is not apparent that continents have been uninterruptedly permanent. Australia and Asia, Africa and Madagascar, New Zealand and Australia, Europe and America, are all supposed to have been united at some more or less remote period; and to explain the present distribution of organisms, seas of a thousand fathoms depth are bridged over as often as it happens to be deemed requisite. But it is still questionable whether these former land connexions, which are admitted by Mr. Wallace, will be found sufficient to explain all the past as well as present peculiarities of distribution. For instance, a much more southerly land connexion between England and America seems required to explain the presence of tropical American plants, such as palms, in our Eocene, because their absence in beds of corresponding age in the United States and Greenland implies that they did not pass along the northern route traced out for them. If sea-beds have been elevated to the extent of a thousand fathoms, and if there are forces capable of elevating the highest mountains in the world from below the sea level within a comparatively recent period, why are 'hypothetical continents bridging over the deep oceans' 'so utterly gratuitous and entirely opposed to all the evidences at our command,' as Mr. Wallace wishes us to believe? There appears to be no valid reason why Europe should not have been connected with South America, by the so-called Atlantic ridge, or even Australia with South America by way of Easter, Gambier, and the Fiji Isles; for if these great banks, with islands occasionally rising to the surface, do not mean changes of level in the sea bottom, whether of elevation or depression, what do they mean?

To take other instances, in which Mr. Wallace's explanations do not seem to be the best solution of the facts. Sir Joseph Hooker, in his singularly interesting introductory essay to the New Zealand flora, stated that seventy-seven plants are common to New Zealand, Tasmania, and South America, comparatively few of which are universally distributed species. Further, there are upwards of 100 genera or well-marked groups of plants almost confined to lands of the south temperate zone, effecting 'a botanical relationship or affinity between them all, which every botanist appreciates.' For reasons which appear to be unanswerable, he has rejected the theory that these plants were transported across the seas which now separate these lands, and considers that the plants of the Southern Ocean are 'the remains of a flora that had once spread over a larger and more continuous tract of land than now exists in that ocean,' and that this land had been broken up by climatic and geological causes. Mr. Wallace supposes an emigration to have taken place from Chili by way of the South Shetland Isles, 500 miles south of Cape Horn, thence by way of an antarctic continent or group of isles, which probably extend around the South Polar area to Victoria Land, again on to the outlying Young Island, across 750 miles of sea to Macquarie Island, and, finally, across another similar distance to the 1000 fathom line, which, he considers, 'probably marks the former southern extension of Tasmania.' This appears a route beset with obstacles both climatal and geographical, and broken up by extents of sea, which Sir Joseph Hooker has expressly stated many of the plants common to these remote lands to be specially unfitted to traverse.* The bed of the ocean is as undulating as the surface of the land; and this is hardly the condition it would have assumed had its state been that of eternal rest. The objection that oceanic islands, with the exception of New Zealand and the Seychelles, hardly ever afford traces of Palæozoic or Secondary formations, and cannot therefore be remains of continents, is far from insuperable. The smaller oceanic islands, to which the statement alone seems to apply, would, if belonging to continental areas, be only the summits of mountains that are either rising or sinking; and as they are mostly of comparatively recent volcanic origin, it is hardly likely that we should meet with Palæozoic or Mesozoic stratified rocks exposed on them. It is even more curious, if they have been uplifted from the great depths which surround them, that no traces of the bottom sediment, which must have been accumulating continuously from the Palæozoic period, should have been brought up with them. Speculation is, however, useless, for the only geological fact regarding them about which we can be certain is that whatever secrets they have to disclose lie buried deeply under volcanic outbursts. It is certainly strange that Mr. Wallace makes no difficulties whatever in admitting changes of level in the sea bottom to the extent of 1000 fathoms, but will not entertain the possibility of any greater upheaval. Yet some oceanic islands must have been upheaved from vastly greater depths, and mountain chains have been raised to three times that extent in comparatively recent times.

It is well known that these forces are unceasingly acting, yet no reason is put forward to show why an elevating force once set in action in the centre of an ocean, should not continue gradually to act until even a continent is formed. In the words of Prof. Huxley, 'Surely there is evidence enough and to spare that the Cretaceous sea, inhabited by various forms, some of whose descendants Sir W. Thomson, as I believe justly, recognizes in the present deep-sea fauna, once extended from Britain over the greater part of central and southern Europe, North Africa and Western Asia to the Himalayas. In what possible sense can the change of level which has made dry land of, and sometimes mountain masses of, nine-tenths of this vast area, be said, to be "in direct relation to the present existing coast-lines." That the abyssal plains were ever all elevated at once is certainly so improbable that it may justly be termed inconceivable; but there is nothing, so far as I am aware, in the biological or geological evidence at present accessible to render untenable the hypothesis that an area of the mid-Atlantic, or of the Pacific sea-bed, as big as Europe, should have been upheaved as high as Mont Blanc, and have subsided again any time since the Palæozoic epoch, if there were any grounds for entertaining it.'[*]

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* The elevation of from 400 to 1300 feet which Chili and Patagonia have undergone for several hundred miles since the existence of the living species of Mollusca must imply at least correspondingly great subsidence elsewhere.

It is so obvious that the causes which lead to elevation and subsidence must react one upon the other, that I am tempted to speculate upon them and their effects on deep-sea basins. I have long been struck with the almost universal tendency to depression exhibited in areas occupied by deltas and estuaries. The thought has occurred to many, and has perhaps been most clearly expressed by Dr. Charles Ricketts, that this subsidence is produced by the accumulation of sediment.[†] The cause appears insignificant, yet something must determine the movement of the Earth's crust, and even an accumulation of a few feet of clay over several square miles may create disturbance, and eventually lead to a downward tendency. Supposing a sediment, 50 feet in depth and entirely submerged, to have displaced an equivalent of sea-water, we should have an increased pressure per square yard, taking the mean density of the materials composing a delta at 120 lbs. per cubic foot, of rather more than 25,000 lbs., or about 34,848,000 tons per square mile. As soon as the whole of the sea-water on an area is displaced and movement has set in, every cubic yard of sediment deposited adds a weight of about 3240 lbs.; and when we see that deltas have accumulated to depths of perhaps even beyond 1000 feet, and extend, as in the Mississippi, to 19,450[‡] square miles, we can realize how vast a force is present.

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[*] Review of the first volume of the publications of the *Challenger*. *Nature*, vol. xxiii. p. 1.

[†] *Geol. Mag.* 1872, vol. ix. p. 119.

[‡] *Report on Mississippi U. S. War Department*, 1864, p. 434.
Records of borings in deltas are, the Po, 500 feet, Ganges, 481, Mis-

The inference as to the origin of depression, which can be drawn from delta and estuary areas, may equally be applied to coral-reefs and islands, and even to great accumulations of ice, as in Greenland; for in almost all such situations there appears to be a nearly continuous downward tendency. There are even grounds for supposing that the depression generally observable round sea-coasts may be due to a similar cause. The sediments from the wasting of the shore* are known to be thrown down almost wholly upon a belt thirty miles wide. The moving power of waves is not felt to a greater depth than forty feet; and it is therefore difficult to explain, except upon the the theory of subsidence, why in the absence of currents, the sea in proximity to shore should ever be more than forty feet deep. All ancient lands should be surrounded by extensive shoals of uniform depth, for tides appear to have no permanent action in removing sediment, and shore-currents of the requisite power are local. The prevailing action, indeed, on our own coasts appears to be silting, if we may judge from the way wrecks become imbedded; and the evidences of subsidence are innumerable. The records of submerged land vegetation are frequent, and though, on the other hand, there are in many places raised beaches, it should be remembered that while these are always conspicuous, depressed beaches cannot easily attract notice.

If it were once conceded that sedimentation directly caused subsidence, we should discover a reason for the permanence of ocean basins, for deposition must have been unceasing since Palæozoic times, and would to a large extent have filled in the depths of the ocean were this action not compensated by constant and gradual depression, exceeding perhaps the rate of sedimentation. The mean of four experiments made on the *Challenger* expedition, determined the quantity of carbonate of lime in the form of living organisms in the surface waters to be 2·545 grammes, so that if these animals were equally abundant in all depths down to 100 fathoms, it would give 16 tons of carbonate of lime to each square mile of 100 fathoms depth.†

The weight of sediment must exercise enormous pressure, tending to make the *greatest depths* of the sea permanent, and to continually elevate lines of least resistance into ridges or banks, leading where the state of tension is extreme, to

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sissippi, 630, in which the lowest beds reached were turf and vegetable matter. The total thickness of many deltas, such as that of the Ganges, may be inferred from the depth of the sea in which they are accumulating.

* The denudation has been estimated to equal nineteen feet in 1000 years.

† In great depths shells are reduced to bicarbonate, and this may imply loss of material. The supply of lime does not seem, however, to be obtained to any great extent from dead organisms, but is probably kept up by rivers.

isolated volcanic outbursts. The lines of absolute least resistance would probably, however, generally coincide with sea-margins, and upon coasts, therefore, while we might find a tendency to local depression, owing to the littoral sedimentation at a few miles from land, there would be inland a far more important and preponderating tendency to elevation.

Thus there would ever be a direct action deepening ocean basins where they are deepest, and raising up the shallower parts to higher levels, thereby slowly lessening the superficial area occupied by seas. On the other hand, the dry land would extend in a corresponding degree, and its surface become more diversified, for new mountain chains would in succeeding ages have a tendency to greater and greater elevation.

I think all we are able to gather from the records of Palæozoic rocks points to a comparative uniformity in the condition of the earth's surface in remote times, there being neither evidence of great depths in the sea, nor of mountainous elevations in the land. These conditions, to judge from palæontological evidence, were increasingly modified during the Secondary period, and on to the present day; so that the theory that increasing weight causes increased depth, derives support from the Geological Record.

PRELIMINARY NOTE ON THE EXISTENCE OF ICE AND OTHER BODIES IN THE SOLID STATE AT TEMPERATURES FAR ABOVE THEIR ORDINARY MELTING POINTS.

By THOMAS CARNELLEY, D.Sc.,
Professor of Chemistry in Firth College, Sheffield.*

IN the present communication I have the honour to lay before the Royal Society a detailed description of experiments, proving that under certain conditions it is possible for ice and other bodies to exist in the solid state at temperatures far above their ordinary melting points. On a future occasion I hope to submit to the Society a full account of the investigation of which these experiments form a part, together with the conclusions to be drawn therefrom. The bodies whose behaviour I propose to discuss at present are ice and mercuric chloride.

Ice.

In the case of ice the great difficulty to be overcome is to maintain the pressure in the containing vessel below 4·6 millims., *i. e.*, the tension of aqueous vapour at the freezing point, for it will be easily understood that if the ice be but slightly heated the quantity of vapour given off would soon be sufficient to raise the pressure above that point. After several fruitless attempts the following plan, involving the principle of the cryophorus, was adopted.

A strong glass bottle, such as is used for freezing water by means of Carré's pump, was fitted with a cork and glass tube C (fig. 1), and the cork well fastened down by copper wire and paraffin wax. A and C were then filled with mercury, and C connected with the end of the tube DE by means of the piece of stout india-rubber pump tubing B, a thermometer having been previously attached by the wire *x* to the lip of the tube

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* From the *Proceedings of the Royal Society*, 1881, No. 209.

B. The connexion at B was made tight by fine copper
. The tube DE was about one inch in diameter, and about
feet long from the bend to the end E; after connexion
C it was completely filled with mercury, care being taken
xpel the air from A, C, and DE as completely as possible;
whole was then inverted over the mercurial trough F, as

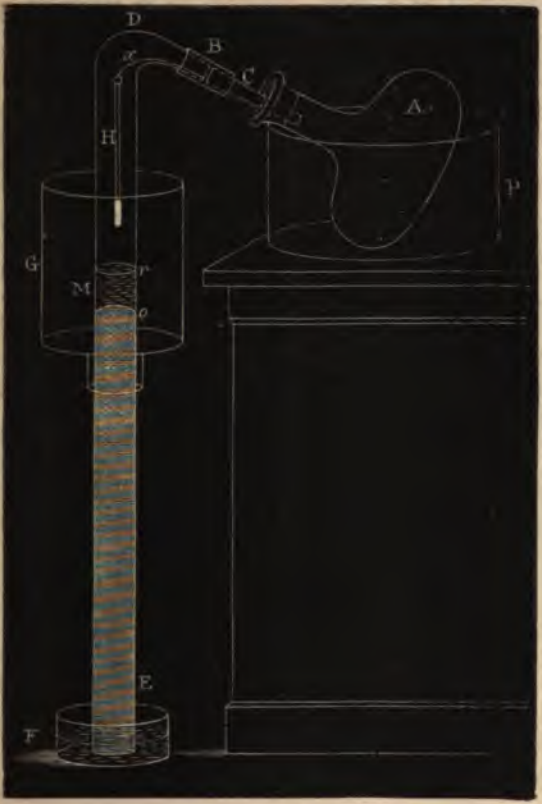

Fig. 1.*

wn in the figure, when the mercury fell to *o*, the ordinary
ght of the barometer. The mercury was run out of A by
ing up the bottle and inclining the tube DE. By this means a
rricellian vacuum was obtained from A to *o*. DE was next
ught to the vertical, and the bottle A placed in the trough P.
in bottle G without a bottom was fitted with a cork, so that
night slide somewhat stiffly along DE.

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* For the use of this and the following figures we are indebted the
lness of the President of the Royal Society.

[illegible]

[illegible]

[illegible] thermometer rose to temperatures vary- [illegible] in different experiments, when the [illegible] had become detached from the bulb of the thermometer. The ice attached to the latter did not perfectly fuse at the commencement of the heating, because, the heat reaching the outer surface of the ice first, [illegible] could take place from a free surface, and the vapour not become imprisoned, as was the case with the ice attached to the sides of the tube.

These experiments were repeated many times, and always with the same result, except in one case in which the heat applied had been very strong indeed, and the ice attached to the sides of the tube fused completely. On removing the lamp, however, for a few seconds the water froze again, notwithstanding that the portion of the glass in contact with it was so hot that it could not be touched without burning the hand.

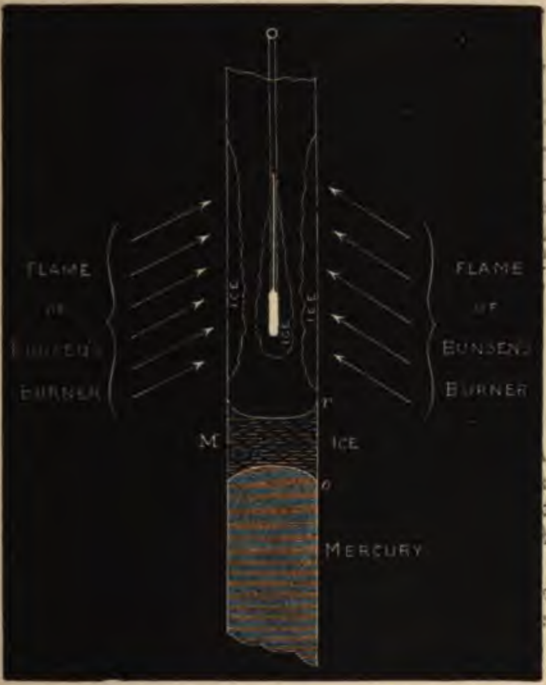

FIG. 2.

The chief conditions necessary for success appear to be—(1) That the condenser (A, fig. 1) is sufficiently large to *maintain* a good vacuum. In the present case the capacity was about three quarters of a litre; (2) That the ice is not in too great mass, but arranged in thin layers. Further, in the case where the heat is applied to the under surface of the layers of ice, the latter must be sufficiently thin to allow of a vent-hole being formed for the escape of the steam coming from below, otherwise fusion occurs. When the heat is applied to the free surface of the ice, the layers may be much thicker.

Mercuric Chloride,

m. p. = 288° C., re-solidifies at 270–275°, b. p. = 303°.

About 40 grs. of pure mercuric chloride were placed in the tube (A, fig. 3), and a thermometer arranged with its bulb imbedded in the salt. The drawn-out end of the tube was connected by stout india-rubber tubing with one branch of the three-wayed tube B, whilst the other was attached to the manometer C. B was connected with a Sprengel pump, fitted with an arrangement for regulating the pressure.

When the pressure had been reduced by means of the pump to below 420 millims., the mercuric chloride was strongly heated by the flame of a Bunsen's burner, with the following results:—

Not the slightest fusion occurred, but the salt rapidly sublimed into the cooler parts of the tube, whilst the unvolatilized portion of the salt shrank away from the sides of the tube and clung tenaciously in the form of a solid mass to the bulb of the thermometer, which rose considerably above 300° C., the mercury of the thermometer shooting up to the top of the stem. After slight cooling the air was let in, and under the increased pressure thus produced the salt attached to the bulb of the thermometer at once melted and began to boil, cracking the tube at the same time.

The experiment was next varied as follows:—

About the same quantity of chloride was placed in the tube A, fig. 3, as before, and heated by the full flame of a Bunsen's burner. The lamp was applied during the whole of this experiment, and the size of the flame kept constant throughout. The mercuric chloride first liquefied and then boiled at 303° under ordinary pressure, and whilst the salt was still boiling the pressure was gradually reduced to 420 millims., when the boiling point slowly fell to 275°, at which point the mercuric chloride suddenly began to solidify, and at 270° was completely solid, the pressure then being 376 millims. When solidification was complete the pump was stopped working, but the heat still continued to the same extent as before. The salt then rose rapidly to temperatures above that at which a thermometer could be used, but not the least sign of fusion was observed. From the completion of the solidification to the end of the experiment the pressure remained at about 350 millims.

[illegible]e above experiment, which was repeated three times, shows, therefore, that when the pressure is gradually reduced from the ordinary pressure of the atmosphere to 420 millims., and the boiling point simultaneously from 303° to 275°, the salt solidifies while it is still boiling and in contact with its own hot liquid, notwithstanding that it is being strongly heated at the same time; and that, after solidification is complete at 270°, the temperature then rises far above the ordinary boiling point (303°) of the substance without producing any signs of fusion.

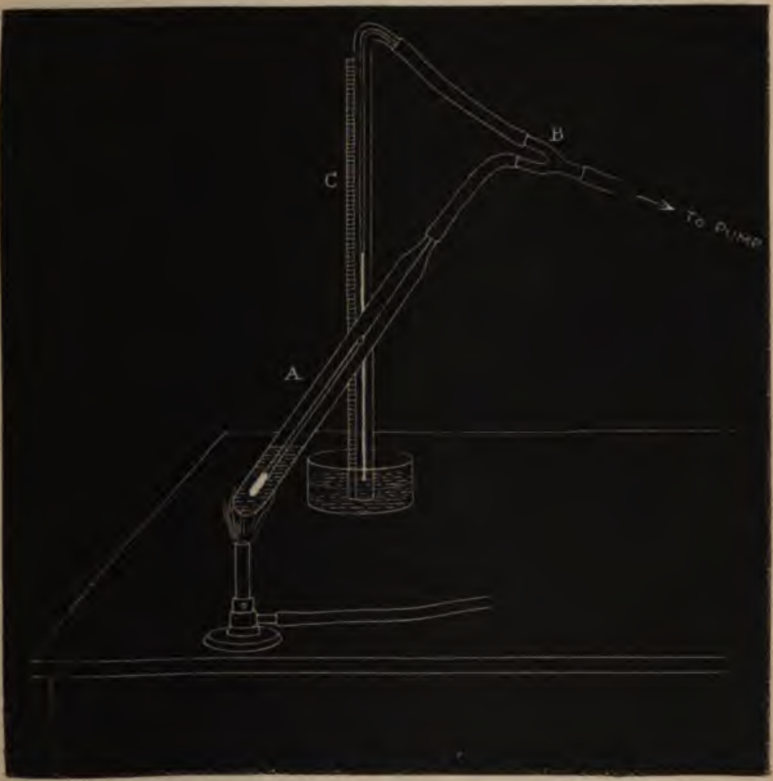

Fig. 3.

Under ordinary circumstances, mercuric chloride melts at 288° and re-solidifies at 270—275, *i. e.*, at a temperature identical with that at which it solidifies under diminished pressure, as above described.

The solid mercuric chloride obtained on solidification under the combined influence of diminished pressure, and the application of a strong heat had a peculiar appearance, quite diffe from that produced when the substance is allowed to solidify in the ordinary way. It appeared to consist of a mass of pearly leaflets closely packed together round the bulb of the thermometer.

Any final explanation of these phenomena is reserved until further experiments have been made.

Since writing the foregoing, it has been said in explanation of the phenomena therein described, that the thermometer, though imbedded in the mass of the ice, did not really indicate the true temperature of the latter. With the object, therefore, of proving whether the ice is hot or not, I have, at the suggestion of Professor Roscoe, made the following calorimetrical determination:—

The arrangement of the apparatus was so modified, that the ice, after being strongly heated, could be suddenly dropped into a calorimeter containing a known quantity of water of known temperature. The resulting temperature, after the ice had been dropped in, was read off by a thermometer graduated so as to indicate a difference of 0°·05 C. The weight of the ice was found by re-weighing the calorimeter.

So far, I have only had the opportunity of completing the two following determinations, and in the second of these the weight of the ice could not be found, as a small quantity of water was lost out of the calorimeter, owing to a sudden jerk at the moment the ice entered it:—

(1.) Weight of water in calorimeter, including the value of the latter = 185 grms.

Weight of ice dropped in = 1·3 grms.

Temperature of calorimeter before . . = 13°·4
" " after . . = 13·6
Rise in temperature = 0·2

$$M(\theta - t) \quad + \quad 80\,W \quad = W(T - \theta)$$
$$(185 \times 0{\cdot}2) + (80 \times 1{\cdot}3) = 1{\cdot}3(T - 13{\cdot}6)$$

$\therefore$ T = 122° C. Where T = temperature of ice.

(2.) Weight of water in calorimeter, &c. = 185 grms.

Temperature of calorimeter before . . = 12°·7
" " after . . = 12·8
Rise in temperature = 0·1

On weighing the calorimeter after the experiment, the increase in weight was only 0·15 grms., but as a portion of the water had been jerked out during the operation, the true weight of the ice, and therefore its temperature, could not be found. But since the calorimeter had slightly risen in temperature, the ice must have been above 80° C.

From the nature of the experiment, as carried out on the present scale, the weight of the ice which can be dropped into the calorimeter is only small, and therefore the rise in temperature is but slight. But since a fall in temperature of a much larger amount ought to have been obtained had the ice been at 0°, it is considered that the above experiments are conclusive. Great care was taken, in order to obtain correct temperatures in the calorimeter. The latter was enclosed in several casings, and the water was allowed to stand in it for several hours before the experiment, so that it might first attain the temperature of the room, whilst the time which elapsed between the readings of the thermometer before and after the ice was dropped in would not be more than from 10 to 15 seconds.

In the course of the next few weeks I intend to make one or two more determinations, and, if possible, on a larger scale.

ON THE FORMER EXISTENCE OF THE ROE-DEER IN ENGLAND.

By J. E. HARTING, F.L.S., F.Z.S.

IT is always a pleasing exercise of the understanding to investigate the causes which produce important changes in animated nature; and this is especially the case when those changes have relation to our own country, and to animals which, once common here, have from one cause or another become extinct.

Our old English foresters were wont to distinguish three classes of game, namely, Beasts of Venery (or of the forest), as the Hart and Hind, Boar and Wolf; Beasts of Chase, as the Buck and Doe, Fox, Marten, and Roe; and Beasts and Fowls of Warren, namely, the Hare, Coney, Pheasant, and Partridge.

When Turbervile, three centuries ago, wrote his *Book of Hunting*, and woodcraft in all its branches was accounted an essential part of a gentleman's education, the Roe-deer held an important place amongst the 'beasts of chase.' During its first year it was termed a *kid*, the second year a *gyrle*, the third year a *hemule*, the fourth year *a Roebuck of the first head*, and the fifth year *a fair Roebuck*. When several were seen together they were spoken of as a *bevy* of Roes; and the season for hunting them was between Easter and Michaelmas for bucks, and between Michaelmas and Candlemas for does. While a hart was 'harboured' and a buck 'lodged' in the fern or underwood, a roe was said to be 'bedded.' The voices of all three were distinguished, and it was said the Red-deer 'belleth,' the Fallow-buck 'groaneth,' and the Roe-deer 'belloweth.' The first named was tracked by his 'slot,' the second by his 'view,' the last by his 'foil;' and, in the ancient jargon of the chase, various were the terms applied to each when hunted.

It is not a little curious that of the three species of deer which were once plentiful in England, the smallest should be the first to become extinct.

One would have supposed that its diminutive size, its timid disposition, and retiring habits, combined with fewer requirements as regards food, would have enabled it to linger on and hold its own in the remnants of our ancient forests, and even in smaller coverts where its allies, the Red-deer and the Fallow-deer, from their conspicuously larger size could not hope to escape detection. This might have been so had it not been for the important circumstance that both the Red-deer and Fallow-deer were at an early period taken directly under man's protection by being enclosed in parks on the first distribution of forest lands.

The Roe-deer not only disdained such protection, no ordinary park-paling being high enough to keep it within bounds, but its wandering disposition necessitating a great tract of country to roam over, rendered it unable to brook the confinement to which the larger animals soon became accustomed. Under these circumstances other causes soon supervened to bring about its extinction. Deprived of the protection afforded to other deer, the destruction of its native woods and the gradual cultivation of moors and waste lands placed it more than ever at the mercy of its enemies. It would be easily approached and killed, its size rendering it a good mark; and on the other hand its slow rate of increase (bringing forth but once a-year, and having usually but two fawns at a birth), would be insufficient to counteract the destruction to which it became continually exposed.

That the Roe-deer must at one time have been plentiful in England, and very generally dispersed throughout the country, is made apparent in a variety of ways.

To turn, first, to the geological evidence. Its remains have been discovered in such widely distant and dissimilar situations as in the barrows and bone-caves of Derbyshire,[*] in the peat of Berkshire and Hants,[†] in the deposits of the Thames Valley,[‡] in the lower marl of the Vale of Kennet,[§] and in the caverns of Devonshire.[‖] That it was at one time a native of the eastern counties of England may be inferred from the discovery of its horns and bones mingled with those of the Red-deer and other animals, now extinct, in the soil of an ancient submerged forest which has been found to extend for more than forty miles along the coasts of Norfolk, and which during the prevalence of very low tides is traceable here and there by the numerous stumps of trees which may be seen still standing erect with their roots attached to them, and penetrating in all directions into the loam or ancient vegetable soil on which they grew.*

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[*] Pennington, *Notes on the Barrows and Bone-caves of Derbyshire*, 1877.

[†] Collet, *Phil. Trans.* 1757, p. 109; Pennant, *Brit. Zool.* vol. i. p. 60.

[‡] Boyd Dawkins, *Pop. Sci. Rev.* Jan. 1868; Woodward, *Geol. Mag.* Sept. 1869, and Walker, *Trans. Essex Nat. Field Club*, p. 38.

[§] *Sussex Archæol. Coll.* xxiv. p. 160.

[‖] Bellamy, *Nat. Hist. South Devon*, p. 440; *Brit. Assoc. Report*, 1869, p. 208.

'The horns of the Roebuck,' says the Rev. Richard Lubbock,† 'are much less frequent in occurrence here than those of the Stag; but a good pair, with part of the skull annexed, were dug up by the turf-cutters on Buckenham Fen, near Attleburgh, and they have occasionally occurred in other situations.'

If we dip into the records of bygone days we shall find that the Roebuck is very anciently mentioned as a beast of chase. The British name for it was *Iwrch.* In the *Colloquy of Alfric* it is included amongst the different kinds of game which the Saxon hunter usually pursued. 'I take harts, boars, and deer,' he says, 'and roes, and sometimes hares.' When asked how he practises his craft he replies, 'I braid nets and set them in a convenient place, and set on my hounds that they may pursue the beasts of chase, until they come unexpectedly to the nets, and so become entangled in them, and I slay them in the nets.'

The practice of taking Roe-deer in nets is referred to in Domesday as being in vogue in Lancashire at the date of the Conquest. Thus, '*Rogerius de Laci teñ Cortune. Ibi est haia capreolis capieñd.*'

The haia, haye, or haie, as it is variously spelled, properly signified the hedge or fence enclosing a forest or park, but by an easy metonymy the word was transferred from the enclosing fence to the area enclosed by it.‡ In the case of the Roe-deer it doubtless implied an enclosed area into which the animals were driven, and having outlets here and there across which nets were hung for their entanglement and capture. The existence of such 'haies' may be found noticed in ancient grants of land during many subsequent centuries.§

Under the Welsh laws of Howel Dha, A.D. 940 (cap. xix.), the skin of a Roebuck was worth a penny, of a Hart eightpence, of a Hind sevenpence.‖ The Welsh name for the Roe was *Iyrchod.*

At the time of the Conquest, Roe-deer were to be found

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[*] Lyell, *Antiquity of Man.*

[†] Lubbock, *Fauna of Norfolk.*

[‡] For a full and interesting explanation of this word see Whitaker, *History of Whalley,* vol. i. p. 283.

[§] See Blount's *Ancient Tenures.*

[‖] An English translation of these laws will be found appended to *The Myvyrian Archæology of Wales, collected out of Ancient Manuscripts,* ed. Owen Jones and others. (Denbigh, 1870.) *Vide* p. 1056.

in the isle of Ely. From an account of the natural productions of this island, drawn up for the information of the Conqueror, and embodied in what is now known as the '*Liber Eliensis*,' it appears that Ely at that date was remarkably fertile in its resources, not only affording pasturage to numberless flocks and herds, but yielding plenty of fish and wild fowl, as well as harts and hinds, roes and hares, which abounded in its woods.* William the Conqueror punished with the loss of eyes any who were convicted of killing a wild boar, stag, or roebuck.

In the year 1183, Bishop Pudsey caused a survey to be made of the various estates of his see in the county of Durham, with a specification of their respective tenures, rents, and services. This survey is generally called the 'Boldon Book,' Boldon being the first place mentioned in it. From entries in this book, it appears that the early Bishops of Durham were mighty hunters, and their tenants often held lands by the service of protecting the deer, and furnishing horses, greyhounds, and other dogs for the chase. It appears, moreover, that the *villani* and farmers were wont to assemble from time to time at the summons of the Bishop, for the purpose of constructing 'haies,' and assisting at a roe-hunt:—

'*Omnes villani de Aukelandschire scilicet de North Aukeland et West Aukeland et Escumba et Newtona . . . faciunt partem suam de haia circa logias. . . . Præterea omnes villani et firmarii eunt in "rahunt" ad summonitionem Episcopi.*' †

In this same county is a place called Reshope, otherwise Reshoppe and Rosheppe,‡ *i. e.*, Roe's hop, or jump, in all probability indicating some famous 'deer-pass' in the days when these animals were common in Durham. So also in Lancashire, its former occurrence in Bowland, says Whitaker, is pretty plainly indicated in the perambulation by the word 'roe-cross.'

In ancient charters conveying the royal license to enclose certain forest-lands, or to hunt in particular counties or districts, the Roebuck is sometimes mentioned amongst other animals which might be enclosed or hunted. Thus from a charter of liberties granted by King John, when Earl of Morton, to the inhabitants of Devonshire, it appears that Roe-deer at that date were included amongst the beasts of chase in that county. This deed, the original of which is still preserved in the custody of the Dean and Chapter of Exeter, is under seal, and provides, *inter alia*, as follows:—

'*Quod habeant canes suos et alias libertates, sicut melius et*

* See *Fenland Past and Present*, p. 356.

† *The Boldon Book*, p. 26 (Surtees Society), and Raine, *Hist. Acct. of the Episcopal Palace of Auckland*, p. 5.

‡ *The Boldon Book*, p. 6.

liberius illas haberunt tempore ejusd. Henrici regis et reisellos suos, et quod capiant capreolum, vulpem, leporem, etc., ubicumque illa invenirent extra regardum forestæ meæ.'

It will be observed that the word here employed is *capreolus*; in many old grants, however, the term used to designate the Roebuck is *caprea*, which, from its similarity to *capra*, has led some translators to suppose that the goat was intended. But, in the first place, the context usually shows that the animals included in a licence to hunt, or to enclose, are beasts of the forest or of chase, while the goat does not fall within either category, being rather an animal of the hillsides and mountains; and, in the next place, contemporary translations of such passages go to prove that, even in cases where the term employed is *capra*, or *caper* (perhaps so written in error by the transcriber), the animal so designated is evidently the Roebuck.*

In the time of Edward III., there were plenty of Roe-deer in the ancient forest of Pickering, in the North Riding of York; and in 1340 a prosecution by the Crown was instituted against Henry de Percy, lord of the adjacent Manor of Semere, for allowing his woodward to carry a bow and arrows, and chase and take Roe-deer within the limits of this forest. It appears, however, that the defendant established a right of free-warren, and pleaded that the Roe was a beast of warren and not of the forest.† Perhaps it was on this case that Lord Coke relied, in holding the Roe to be a beast of warren, a decision opposed to the opinion of many old English writers on venery, who included this animal amongst the beasts of chase.

We learn from Holinshed, that in Henry the Fifth's time (1413–22), deer were so numerous in England as to be very destructive. 'Although,' he observes, 'of themselves they are not offensive at all, yet their great numbers are thought to be very prejudiciall, and therefore justly reproved of many. Of these also the stag is accounted for the most noble game; the fallow deere is the next, then the roe, of which we have indifferent store.'

The author of the ballad of 'The Battle of Otterbourne' was guilty of no anachronism, when in the following lines he introduced the Roe as one of the characteristic animals of Northumberland in 1388.

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* A case in point is furnished by John of Trevisa's translation of the *Polychronicon* of Ranulphus Higden, to which we shall presently have occasion to refer.

† *Placita coram Rege apud Westm. Term Hil.* 13 Ed. III. *Rot.* 106, *Ebor.*

'The roo full rekeles ther sche rinnes
To make the game and glee,
The fawkon and the fesaunt both
Amonge the holtes on hee.'

For, a hundred and fifty years later, Leland was able to testify that this animal was then still common in the north of England. He remarks in his *Itinerary*, 'In Northumberland, as I heare say, be no forests except Chivet Hills,* and there is great plenty of redde deare and row-bukkes.' According to a Report of Royal Commissioners furnished to Henry VIII. in 1512, there were nearly 6000 head of deer, Red, Roe, and Fallow, in the forests and parks of the Earl of Northumberland in the northern counties, at which date there were Red-deer in the forest of Rothbury.†

About 1530–34, as we learn from the *Durham Household Book*, Roe-deer were to be found in the adjoining county. Thus at p. 142 we find the entry:—

'*Et Eduardo Denynge et Johanni Greynsweyrde, per* 4 *dies apud Mugleswyk* [Muggleswick] *deferentibus* 4 *roys in regardis* . . . . 12*d.*'

Here it is evident from the context that Roe-deer are intended, for the entries which precede and follow this all relate to venison brought in. At times the Latin name is bestowed, but generally the English; thus we find:—

'*Et famulo Abbatis de Fountanc' deferenti* 1 *buk bursario.* 3*s.* 4*d.*'

'*Et Thomæ Harper deferenti damam domino Priori, Dominica prima Adventus à Roberto Crosby* . . . . 20*d.*'

'*Et Lionello Smyth et Eduardo Denynge deferentibus* 1 *stage à Mugleswyk* . . . . 20*s.*'

The existence of Roe-deer in Wales was noted by Leland in Henry VIII.'s time; and Camden has noticed several Welsh localities which from their name seem to indicate former haunts of this animal, as Bryn-yr-Iwrch, Phynon-yr-Iwrch, Lhwyn-Iwrch, &c. Pennant informs us that, according to Dr. Muffett, they were still to be found there in the reign of Elizabeth.‡ On turning to Dr. Muffett's work,§ we find the bare statement (p. 75) that 'the Alps are full of them in high

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* It is curious that Leland should have made this statement, for beside Cheviot, there were in Northumberland the forests of Rothbury, Redesdale, Eresdon, Lowes (anciently Loughs, from the number of lakes in it), Allendale, and Knaresdale.

† Wallis, *Nat. Hist. and Antiq. of Northumberland* (1769), vol. i. p. 410.

‡ *British Zoology*, vol. i. p. 59.

§ *Health's Improvement*, by Dr. Thomas Muffett, corrected and enlarged by Christopher Bennett, 1655. The author died in 1590, but it does not appear that there was any earlier edition of his work than that of Bennett, who probably revised the original MS. See Wood's *Athenæ* (ed. Bliss), vol. i. p. 575.

Germany, and *some of our mountains of Wales are not without them.*' It is to be regretted that Dr. Muffett did not particularize the localities in Wales where he supposed the Roe-deer to exist, for a contemporary of his expresses a very different opinion. George Owen, of Henllys, writing of the wild animals of Pembrokeshire in his time (1595), informs us that 'for Roes, the countrey yeeldeth not any, neither did I ever heare of any by reporte of the auncient men, to have been usual in this countrey.'*

One of the most interesting records which we have met with in the course of our researches on this subject, is that which relates to the transport of some Roe-deer from Cumberland to Surrey in the reign of Charles I. The king had expressed a wish to have some turned out at Wimbledon in one of the royal parks, and application was made to Lord William Howard of Naworth Castle, Cumberland (where we may presume Roe-deer were then common), to have some caught and sent up. Directions for this purpose were accordingly given, and what followed may be gathered from the following entries in the *Household Book* of the owner of Naworth:—

'1633, June 29.—To severall persons for takeinge 31 Roe-kidds, as appeareth by bill . . . vijli xijs vjd.'

They were, no doubt, taken in a 'haie' with nets, according to the ancient practice; and after being kept in an enclosure for a fortnight until they had got more tame and accustomed to confinement, they were ready to be moved to London. This was accomplished by means of three carts, as we learn from the next entry:—

'1633, July 16.—To Wm. Lancaster the Smith, for binding 3 payre of wheeles with iron which carried Roes to London . . . . vli xvjd.'

And subsequently on the return of these carts:—

'For repairinge 3 cartes sent with Roes to London to Kinge Charles thether and home again . . . xvs. xd.'

How these animals fared in their new home in Surrey we are not accurately informed; but it may be surmised that they throve and did well, for a few years later, viz., on January 17, 1639, a warrant was issued to Sir Henry Hungate for 'the preservation of His Majesty's game of Roe-deer broken out of Half-Moon Park, Wimbledon, and now lying in the woods adjoining thereto, and to take care that no person hunt, course, or use any net or gun, within four miles of the said park.'†

When the Roe-deer became extinct in England is not quite certain. In Percy's *Reliques of Ancient English Poetry*, in a footnote to the passage in the 'Battle of Otterbourne' above quoted, it is stated that Roebucks were to be found upon the wastes not far from Hexham in the reign of George I., and that Mr. Whitfield of Whitfield is said to have destroyed the last of them. This is probably the instance referred to by Scott in his *British Field Sports*, who states (p. 381) 'that the last of its race in England was, it seems, killed in Northumberland about seventy years ago;' but, if so, his book having been published in 1818, he would have been nearer the mark had he said 'ninety' or even 'a hundred years ago.'

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* For some notice of this writer and his MSS., see Fenton's *Historical Tour through Pembrokeshire*, 4to, 1811, pp. 524, 562, 563 note, and Appendix, p. 54.

† S. P. Dom. Charles I. ccccix. 105, Docquet.

An exceptional instance, however, of the capture of a wild Roe in Northumberland, occurred early in the present century, and is thus recorded by Bewick in his *History of Quadrupeds* (ed. 1807, p. 148):—'Some years ago one of these animals, after being hunted out of Scotland, through Cumberland, and various parts of the North of England, took refuge in the woody recesses bordering upon the banks of the Tyne between Prudhoe Castle and Wylam. It was repeatedly seen and hunted, but no dogs were equal to its speed; it frequently crossed the river, and either by swiftness or artifice eluded all its pursuers. It happened during the rigour of a severe winter, that being pursued, it crossed the river upon the ice with some difficulty, and being much strained was taken alive. It was kept for some weeks in the house, and was then again turned out, but all its cunning and activity were gone; it seemed to have forgotten the places of its former retreat, and after running some time, it laid down in the midst of a brook, where it was killed by the dogs.'

The late Prof. Garrod, in his recently published account of the *Ruminantia* in Cassell's *Natural History*, vol. iii. p. 63, states that the Roebuck 'still survives in the woods of Westmoreland and Cumberland,' but gives no authority for this statement, nor any further particulars.

The species had probably been extinct in England for some years, when Lord Dorchester, in 1800, turned some out in the woods at Milton Abbey, Dorsetshire, from whence their descendants dispersed in a very short space of time, especially in a south-westerly direction. They were frequently hunted, and afforded excellent sport. About 1829, when the Master of the Hounds, Mr. Pleydell, gave up his pack, after hunting Roe-deer exclusively for sixteen years, he permitted Mr. Drax, of Charboro Park, to capture several of these deer and turn them out in the Charboro Woods. From this second centre they increased in numbers, and wandered far and wide,—from Moreton to Warmwell in the valley of the Frome, and from Hyde to Houghton in that of the Puddle. Their extreme eastern extension at present is Lychett, and they have been met with as far west as Hook Park. Mr. J. C. Mansell Pleydell informed the writer, that in 1879 he estimated there were no less than 120 head in the Milton, Whatcombe, and Houghton Woods, which fringe the southern side of the Vale of Blackmore, from Stoke Wake to Melcombe Park and the Grange Wood westward, the number being merely a question of preservation or non-preservation.*

Chafin, in his *Anecdotes of Cranbourn Chase*, mentions the Roe-deer as an animal indigenous to that part of the country; but as his book was not published until 1816, it seems possible that the presence of the Roes in Cranbourn Chase (where a few are still to be found) may have been due to Lord Dorchester's experiment commenced six years previously. At all events, Chafin says nothing of the existence of the Roe-deer in the Chase prior to 1800.

Dorsetshire is now the only county in England, it is believed, where Roe-deer still exist in a wild state; not because the ancient race have survived there till now, but because, as we have seen, it was reintroduced at the commencement of the present century, by turning out a few brace procured from Scotland.†

In 1810 there were a good many Roe-deer in the woods belonging to the Earl of Egremont at Petworth, Sussex. A skull of one of them (a female, with rudimentary horns) was presented in that year by Lord Egremont to the Museum of the Royal College of Surgeons, where it is still preserved (No. 3598 D),‡ and the abundance of Roes in the Petworth woods at that date, is proved by his lordship's letter which accompanied the specimen referred to, and which is printed in the *Museum Catalogue of Monstrosities*, part v. p. 17.

The writer has been recently informed by Lord Leconfield, the present owner of Petworth House, that there is a tradition to the effect that the Roe-deer were introduced there, and were not the descendants of an ancient stock. About thirty years ago, some were sent as a present to Prince Albert, and were turned out at Windsor, where a few are still preserved in the neighbourhood of Virginia Water. Those which still survive at Petworth are kept in the park, which being surrounded by a wall fourteen miles in length, affords them unusual security and yet abundant liberty.

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* See *The Zoologist*, 1879, pp. 120, 170, 209, 262, 301.

† In addition to the information given on this point in *The Zoologist* for 1879, above quoted, the reader will find further details in *The Sporting Magazine* for 1817, in Scott's *British Field Sports*, p. 381, and in Gilpin's *Forest Scenery* (ed. Lauder), vol. ii. p. 301.

‡ This skull is figured in the *Proceedings of the Zoological Society*, 1879, p. 297, in illustration of some remarks on female deer with antlers, by the late E. R. Alston.

In Scotland, the Roe-deer was once much more common than it is at present, although it is still plentiful in some parts of the country, and has even increased of late years.

It is believed that the increase of plantations in the south of Scotland has been the means of spreading it much further in that direction than it used formerly to be found.

In Ireland the Roe-deer is unknown, and since no remains of it have been discovered, it seems probable that it was never indigenous to that country, although some have asserted otherwise, on the authority of Bede. John of Trevisa, however, in his translation of Higden's *Polychronicon*, observes: 'Beda seith that there is grete huntynge of Roobukkes (*caprorum* is the word used by Higden), and it is i-knowe that Roobukkes beeth noon there. It is no wonder of Beda, for Beda knew nevere that ilond with his eyes; bot som tale tellere told hym suche tales.'* On the other hand, if the testimony of Ossian be admitted, it would seem that the Roe was not uncommon formerly in Ireland. There are many very striking passages in which that poet adverts to the hunting the Roe-deer there. He thus pictures the animal's haunts:—'Lumon of foaming streams . . . . the dun Roe is seen from thy furze; the deer lifts his branchy head, for he sees at times the hound on the half-covered heath.' *Temora*, book vii. Again:—'The king rejoiced as a hunter in his own green vale, when after the storm is rolled away, he sees the gleaming sides of the rocks. The green thorn shakes its head in their face; from their top look forward the Roes.' *Temora*, book viii.

Strange to say, also, the Roebuck is mentioned as a native of Kerry in an Irish MS. poem of the ninth century, which is thus referred to by the late Sir W. Wilde: †

'In the collection of Irish MSS. preserved in the Library of the University of Dublin, is a very curious zoological and topographical poem, the original of which is believed to be as old as the ninth century; it is certainly one of the most remarkable productions of its kind known in any language in Europe of the same date. The history of this poem is as follows:—Finn Mac Cumhaill was made prisoner by Cormac Mac Art, monarch of Erin, who, however, consented to liberate him when a ransom of two of every wild animal in Ireland—a male and female—were brought before him on the green of Tara. Cailte Mac Ronain, the foster-brother and favourite of the celebrated Irish general,[*] having first performed many remarkable feats at Tara in the king's palace, undertook and succeeded in accomplishing this apparently hopeless task within a twelvemonth; and in this poem is said to have related to St. Patrick the result of his mission. There is, perhaps, no other example in the Irish language of the same extent containing so many words—names of animals—of which the meaning is not known; and there are but few poems of so many lines requiring the same amount of topographical annotation. The names of several animals are, as stated, untranslatable; either the animals themselves have become extinct in Ireland, or they are now known by other names than those preserved in the MS.' As a specimen we quote the following lines:—[†]

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* See also *The Book of Howth*, Brewer and Bullen, Calendar Carew MSS. p. 32.

† *Proc. Roy. Irish Acad.* vol. vii. p. 182.

'I then went forth to search the lands,
To see if I could redeem my chief,
And soon returned to noble Tara
With the ransom that Cormac required.

'Two foxes from Slibh Cuilinn [co. Armagh],
Two wild oxen from Burren [co. Clare],
Two swans from the dark wood of Gabhran,[‡]
And two cuckoos from the wood of Fordrum.'

The most remarkable line, however, so far as concerns our present inquiry, is that which relates to the bringing of two Roebucks (*Earbóg*) from Luachair Deaghaidh, *i. e.*, Slieve Lougher, Co. Kerry.

We are not informed upon what authority the word *Earbóg* is rendered 'Roebuck.' It seems not a little curious that the Irish in the ninth century should have had a name for an animal which, it is supposed, was never indigenous to Ireland; at the same time, it should be observed that the Irish name, *Earbog*, closely resembles the Gaelic names for this animal (Earb, Earba, Earb-boc) in use at the present day.

It is worthy of remark, too, that in the Museum of the Royal Irish Academy, amongst the collection of Irish Red-deer horns, is a small specimen catalogued as 'No. 45, a small shed horn, *apparently of the Roebuck*, presented by Joshua Ferguson, Esq.' Not having seen this specimen, we can express no opinion upon it; but if it be really the horn of a Roebuck found in Ireland, its history would be worth tracing.

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[*] See *Annals of the Four Masters*, under A.D. 286.

[†] A translation of this poem appeared in the *Dublin University Magazine*, March 1854, and the Irish version, with the translation opposite, is given in the seventh volume of the *Proceedings of the Royal Irish Academy*, 1859, pp. 184–191.

[‡] Now Gowran, co. Kilkenny.

CONTRIBUTIONS TO THE KNOWLEDGE OF THE HOTTENTOT RACE.

BY M. J. A. ROORDA SMIT.*

DIFFERENT travellers who have had the opportunity of comparing the Hottentots and the Chinese, have found a great analogy between the two races. The first who remarked it were the old colonists of the Cape, who even gave to some tribes the name of 'Chinese Hottentots.' In England, also, John Barrow drew attention to this singular fact.†

When, at a later period, Chinese coolies arrived at the Cape, their resemblance to the Hottentots was found to be striking, and led to frequent errors. Wood speaks of a traveller who believed that he had a Hottentot servant, and who discovered, only after some time, that the man was a Chinese.‡

During my stay in South Africa, I have been more than once witness of similar facts. At the Cape, for instance, I have seen a Chinese and a Hottentot both serving in the same hotel; as they were dressed almost in the same style, we were constantly confounding them, taking the Asiatic for the African, and *vice versa*. At the Diamond fields I met with a case of the same kind.

In order to give a general character of the Hottentots, I cannot do better than quote the following passage from Von Siebold: 'The breadth and coarseness of the face, the prominence of the cheekbones, the development of the jaws, the flattened form of the bridge of the nose, and the enlarged nostrils, the size of the mouth, the thickness of the lips, the apparent obliquity of the eyes, the stiff, abundant hair of a brownish-black colour, or inclining towards red, the heaviness of the eyebrows, the scarcity of the beard; and lastly, a wheat-coloured, yellowish-red complexion distinguish them,' &c.§

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* From the *Archives Néerlandaises des Sciences exactes et naturelles*, tome xv. livr. 5.

† Barrow, *Voyage to Cochin China*.

‡ *Natural History of Man*, p. 241.

§ Prichard, *Nat. Hist. of Man*, vol. i. p. 232; *Catalogue du Musée Vrolik*, par Dusseau, p. 32.

I need only remark, concerning the hair, that among the Hottentots it is curly and does not cover the head uniformly; it forms patches separated by bare spaces. Moreover, as regards the complexion, the expression, 'yellowish-brown,' would be more suitable, at least in certain cases, than 'yellowish-red.'

Now, in giving this description, Von Siebold did not refer to the Hottentots, but to the Mongols who inhabit the Corea, a country tributary to China.

Dr. Carpenter describes the Hottentots in the following terms: 'Thus the face presents the very wide and high cheek-bones, with the oblique eyes and flat nose of the northern Asiatics; at the same time that, in the somewhat prominent muzzle and thick lips, it resembles the countenance of the Negro. The hair is woolly, like that of the Negroes, but it grows in small tufts scattered over the surface of the scalp (like a scrubbing-brush) instead of covering it uniformly; thus resembling in its comparative scantiness that of the northern Asiatics.' *

A long time before the Dutch East India Company had taken possession of the Cape, vessels of other nations had already dropped anchor in Table Bay and made the acquaintance of the inhabitants of the country (1497–1652). But the accounts of these voyages, of which the sole aim was commerce, give us little information about the inhabitants.

The Portuguese, who changed the original name 'Quai-qua, Khoi-khoiu, Kanimou-qua?' into that of 'Saldanhas,' learned more than once, to their cost, that the population, though weak and not numerous, could defend itself and was vindictive. (1497, Vasco de Gama; 1510, Francisco d'Almeida; 1516 (?), Emmanuel de Souza.)

The Dutch and English had rather less to complain of. (1598, John Davis; 1601, English East India Company and Paul de Corniden; 1608, Maaklof; 1648, Leendert, Jansz. and Nic. Proot, Van Riebeek.)

The natives of the Cape received from the Dutch the name of 'Ottentos,' which has since become 'Hottentots.' At the time when the Europeans became acquainted with them, they were nomads, who changed their abode continually and lived in 'kraals,' the huts of which were easy to take down and put up elsewhere. They were acquainted with metals—at all events with iron—which they knew how to work. Their acquaintance with this metal, however, does not seem to have been very general, as it was considered a precious article, although iron ores are not rare at the Cape, particularly in Namaqua-land.

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* Carpenter, *Physiology*, fifth ed. p. 897.

In 1601, the ships of the English East India Company obtained sheep and cattle in exchange for pieces of old iron.

Their weapons were the bow and arrow. When, later on, they came in contact with the Caffres, they adopted from them the 'zagaie.' At the time of the voyage of Le Vaillant (1781), the use of this weapon had spread very little among them, and the Hottentots, who already possessed 'zagaies' had not yet learned to make use of them very cleverly. Their clothing consisted of dressed skins, more or less ornamented. They knew very well how to remove the hair from skins.

A peculiarity which is also found among the Caffres, is the circular form of their huts and of their camps. It seems that no South-African race can easily draw a straight line.

The geographical distribution of the Hottentots is often described incorrectly. To judge of it from my own researches, they must have originally inhabited the south-west side of the Cape, *that is to say, only the coast region!*

While the Hottentots were in possession of the western part of the Cape, the Caffres occupied the eastern part (1500, Cabral). The shipwrecked sailors of Souza's ship reached on the east (eastern coast) an *Ethiopian* village where they embarked. We cannot here imagine any confusion with the Hottentots, seeing that the sailors in question knew the latter perfectly, having seen them before. In 1684 an expedition of thirty-nine Boers found, in the eastern part of the Cape, some Caffres who had never yet seen a white man. It seems that the Hottentots at that time had no knowledge of the neighbourhood of the Caffres. It was probably about 1700 that they came in contact with them. From these connexions have resulted the mixed races of the 'Gonaqua' and the 'Gonaquebi.' When Le Vaillant travelled amongst the Gonaqua (1781), they did not seem to remember their true origin.

The nature of the soil obliged the Hottentots to keep near the southern coast. Further north they would have come upon the great plain of the Karrou, which, from the want of water and good pasturage, would not have suited their cattle at all. So when Le Vaillant visited the Karrou, he found there no other population besides Bosjesmans and Souzouana. By this last name he designates also Bosjesmans, not Bechuanas.

While the Quaiquas occupied the most southern part of the country, they were in contact in the north with the Korannas. Le Vaillant met with the latter in their original station. But towards 1790 they emigrated towards the interior, and established themselves on the territory of the Transvaal, at the part where the Hart's River falls into the Vaal. The old chief, Mossou Ryt Taaibosh, stated, in 1872, to M. Burgers, who was then President of the Transvaal, that when he was about fourteen (at the time of the declaration he was over a hundred) he had set out with his tribe, which had previously inhabited the coast.[*]

To the north of the Korannas, and to the north and south of the Orange river, dwelt the Namaquas. These people, visited for the first time by Van der Stell (1685), appear to have mixed with more northern tribes (not Hottentots), especially with the Damaras; so that the actual representatives of these latter would be partly their descendants. There exists, at least among the Damaras, a legend, according to which they had, as first ancestors, a Namaquan father and (*horribile dictu!*) an ape mother. This legend, which has been told me by hunters, is also spoken of by Wood.[†]

The Bosjesmans are at present sufficiently recognized as Hottentots. All the Hottentot tribes seem to have furnished their contingent to these pioneers. Nevertheless, there is room for thinking that, besides these deserters, they also comprise original tribes; and Le Vaillant even regards these as true and pure Hottentots. They penetrated further than all the others into the Karrou. They were not nomads, but they lived exclusively by hunting.

It was probably at a more distant period that the Bosjesmans (Sa-an or Sa-qua) separated from the other Hottentots. They feared the more northern tribes; as for those who lived more to the south, they seem to have known them but slightly or not at all.

We find on this subject the following curious passage, dated the 24th April, 1654, in the journal of Van Riebeek, the first governor of Cape Colony: 'To-day a dead *Bosmanneken* was found in the mountain, such as is called in Batavia an Ourang-outang. He was about the size of a small calf, with long and hairy arms and legs, and of a dark-grey colour. Forced by hunger, our people ate him.'[‡] I must add, in defence of Van Riebeek, that at this time his relations with the neighbouring Hottentots were not at all friendly, so that he could not gain from them any enlightenment.

The Bosjesmans have always been driven back towards the interior of the country. Nowadays we meet with them nowhere but in the mountains of Basutoland, and in the plains of the Kalihari.

The Hottentots have never been a powerful people. According to the census of 1865 they numbered 81,600 in Cape Colony. Taking all the tribes together, I think we may estimate their total actual numbers at 270,000, perhaps at

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[*] *Correspondence between Thom. Fr. Burgers and Sir Henry Barkly.*

[†] Wood, *Nat. Hist. of Man.*

[‡] Hall, *Manual of South African Geography*, Chron. Tables.

300,000. It is possible that formerly they may have been more numerous, but the difference cannot have been great. They have never suffered very greatly from either war or epidemics. Moreover, considering the climate, the polygamy that was customary amongst them, etc., circumstances were favourable to their multiplication.

I think there is good reason for supposing that in 1500 their number was much smaller than at the present day. They had been unable, before the establishment of the Dutch Colony, to drive back the wild beasts, so dangerous to them and to their flocks. Lions, for instance, were still, in 1563, so numerous on the coast of Table Bay that Van Riebeek wrote in his journal, 'This night one would have said that the lions were inclined to take the fort by storm.'*

Though inhabiting the coast in 1500, and even later, they possessed no knowledge of navigation; so that they had no communication with Robben Island, which was situated opposite Table Bay.

The different tribes of Hottentots may be divided into, 1st, Quai-qua, or true Hottentots; 2nd, the Nama-qua; 3rd, the Koranna, Kora, or Kora-qua; 4th, Sa-an, Sa-qua, or Bosjesmans; 5th, Gonaqua and Gonaquebi—mixed races produced by a mixture of Caffres and Hottentots; 6th, Griqua, a mixed race, one issue of white fathers and Hottentot mothers. Hybrids of Hottentots and white women have never been noticed, as far as I know, and probably they do not exist.

The Griquas united about 1780–1790 into tribes, which abandoned the Cape Colony, and established themselves in the territory now forming the Vrystaat (Free State) and in Griqualand West. More recently, somewhere about 1850, many of the Griquas returned towards the coast in the district called Griqualand East, and formerly known by the name of Niemandsland (No-mans-land).

All the tribes, including the Gonaquas and the Griquas, belong by their physical characteristics and by their language to the same natural group. On the similarity of the language I must remark that the dialect of the Gonaquas is a mixture of the Caffre and Hottentot dialects, and that most of the Griquas speak Dutch.

The language of the Bosjesmans is the poorest of all; one might call it degenerated Hottentot. This fact is easily explained by the very primitive way of life of these pioneer hunters. An analogous example of degeneracy in language and physical characters may be observed now on the north-east borders of the Transvaal, among the Vaalpen Caffres, remnants of the great tribes of the Bechuanas, which have been exterminated by more powerful neighbours. To these Vaalpens, the name of Bechuana-Bosjesmans might very well be given. A characteristic feature of the Hottentot dialect is the use of 'clics,' of which the Korannas particularly make very frequent use.

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* Hall, *Manual of South African Geography*, Chron. Tables.

These dialects differ essentially from the Caffre dialects. Often, indeed, it has been believed (particularly in Cape Colony) that there existed a relationship between the two languages; and some even considered the Hottentot as a modified Caffre dialect. But this opinion is altogether erroneous. Before 1500 the Hottentots had seldom, if ever, come in contact with the Caffres.

The origin of the error in question is easy to discover. When the Hottentots entered into relations with the Caffres there resulted the mixed races of the Gonaquas and of the Gonaquebis, which both of them, and particularly the latter, spread among the Galeka Caffres. Thus the 'clics' and some Hottentot words were introduced into the language of the Galekas. But these 'clics' are only met among those Caffres who border on some Cape Colony, and among the Basutos (in greater part Bechuanas), who about 1830 constituted a distinct people and admitted among them some fugitive Hottentots.

Among the other Caffres, for example among those of Natal and Zululand, no trace either of the 'clics,' or of the other peculiarities of the Hottentot languages, are found. They are equally strangers to the language of the Bechuana, established to the north of the Transvaal.

For some time, however, the 'clics' appear to have a tendency to spread particularly in the south of Natal. As the Gonaquas also moved amongst the Hottentots several Caffre words have obtained a footing in the Hottentot language. The Korannas, after their immigration into the Transvaal frequently mingled with Bechuana tribes (black), and this has also diminished the purity of their language.

In Cape Colony many, if not most of the Hottentots, speak nothing but Dutch, and no longer know their original language. This language is still spoken only and exclusively by the Bosjesmans and the Namaquas. But these have likewise been in more and more frequent contact with the whites and other races. In fifty years their language will perhaps have entirely disappeared.

I have made some researches on the question of the distribution of the races at the Cape, a question which interested me especially. Its study is rendered very difficult by the very frequent change of abode of the different tribes, and as besides I have only incomplete materials at my disposal, the results obtained must be looked upon as merely tentative.

These results may be summed up as follows:—1. The central part of the Cape countries, now known by the name of Karrou, as far as the Orange River, of Vrystaat, of Griqualand West, and of Kalihari, was formerly uninhabited and visited only by the Bosjesmans. From about 1790 the Vrystaat and Griqualand-West were colonized by Korannas and Griquas, and a little later by Bechuanas (Barolongs, Bawanketsis, &c.). The Korannas and the Griquas came from the Cape Colony, taking a direction from south to the north; the Bechuanas arrived from the north—probably from the northern part of the Transvaal.

2. The eastern part of the Cape, to the south of the Stormbergen, along the coast, and to the east of the Drakenbergen (which are a continuation of the Stormbergen), was already inhabited in 1500 by Caffres (British Caffraria, Natal, &c.).

3. The Transvaal was also early inhabited, particularly the northern part, by Bechuana tribes, who were always moving towards the south (1600 ?).

4. The country to the west of the Transvaal, which Livingstone and others have mentioned by the name of 'Sechele's Country,' was only colonized towards the year 1824 by Bechuana tribes (among which were the Makololos, who have since been moving again towards the north), which had been driven away from the Transvaal by the Matabeles of Moselekatse.

The Bechuanas and the Caffres seem to have come from more northern parts of Africa. They show a certain analogy of characters. Their movements were effected parallel to one another from the north to the south; the Caffres proceeding along the coasts, the Bechuanas across the central region. To the south of the Limpopo they were separated by the Drakenbergen, so that the Caffres remained to the east of this mountain range, and the Bechuanas to the west. Both these races are black, and we often find among them, especially among the Bechuanas, Arabian and Jewish types.

5. Basutoland, which was formerly entirely uninhabited, was colonized only in 1830 by Bechuana tribes coming from the Transvaal, and by a small number of Fetcannets (the present Fingoes of the Cape Colony, who before 1820 were Caffres of Natal), of Korannas, of Bosjesmans, &c., whom the chief Moshesh united into one people, under the name of Basutos (1830).

6. The country situated between the two rivers—the Limpopo and the Zambesi, to the north of the Transvaal—was originally occupied by Bechuanas, but later on, after 1836, it was invaded by Caffres—the Matabeles of Moselekatse, who left the Transvaal, and took a direction across Sechele's country, at first towards the west, afterwards towards the north, and still later towards the north-east. In the country of Moselekatse (or rather of his successor, Lo-bengula) some

missionaries (Merensky, &c.) have sought the Ophir and the Saba of the Old Testament. Maude has there discovered the grand ruins of Zimbaye.

The traces of human industry which I have found myself in the Transvaal belong to a rather recent date. Such are several old copper-mines (with quartzose gangues) in the Makhali mountains, a range of quartz porphyry, which, at about six English miles to the north of Pretoria, runs from the east to the west. Such are further old lead-mines, which I have found in the Waterberg district, about eighteen English miles to the north-east of the Nylstroom. Galena, rich in silver, is there disseminated in a vein of quartzite, which has been worked very methodically by open workings. Neither the Bechuanas nor the white population of the district knew by whom, or at what period, these works had been executed. I presume that they are to be ascribed to the Portuguese, who had very early taken footing in South Africa, and who followed trade.

The general conclusion from these researches is, that the Hottentots did not occupy the central part of the Cape. As the fertile plains of the Transvaal and of the Vrystaat were formerly uninhabited, they would have been able to live there quietly, just as well as elsewhere, if they had arrived in the south by this way.

I have reason to suppose that the south and the east of the Cape countries ought to be considered as their original abode. Thus we find, in the fifteenth century, in the southern part of the Cape, a *yellow* race, amounting to from 200,000 to 300,000 souls, bounded on the north by *black* tribes (Damara and Ovampo), and by desert places (Karrou, &c.), and in the east also by black tribes (Caffres).

[The author then makes a detailed comparison of the characters and measurements of Chinese and Hottentot skulls, the general results of which he sums up as follows:—]

If it is allowable to draw general conclusions from the measurement of so small a number of crania, we find:—

1. That the crania of the Hottentots are not only dolichocephalic, but in nearly half the cases (seven out of fifteen) orthocephalic. In general they are more dolichocephalic than the Chinese crania, the length being in them relatively greater, and the width less.

2. That the absolute height of the Hottentot crania is less than that of the Chinese crania. As the length of the first is relatively greater than that of the second, the index H. L. is smaller in the Hottentots.

3. That the Hottentots are in general less prognathous than the Chinese.

4. That the height of the face in the Hottentots is less than among the Chinese, the absolute height, as well as the relative (the index H. L.)

The points of resemblance between the Hottentots and the Chinese consist in—

1. The width of the bridge of the nose (space between the orbits).
2. The shape and inclination of the orbits.
3. The prominence of the zygomatic bones and arches.
4. The width of the face (taken at different heights).
5. The development of the parietal bosses.
6. The relation between the arcs and their chords.

This last character applies above all to the arcs and chords situated in the sagittal plane; in a less degree to the transverse arcs and chords.

If we consult the works of Blumenbach,* of Van der Hoeven,† of Lucae,‡ of Von Baer,§ of Retzius,‖ of Dusseau, of de Koning,¶ and others, we find indicated as fairly constant characters of the Chinese crania,—

1. A wide bridge to the nose, and a broad flat nose.
2. The facial surface of the upper jaw, but little hollowed, and often even convex (Dusseau).
3. The zygomatic bones and arches very prominent.
4. The parietal bosses well marked, and often very much developed.
5. A curvature with the convexity anterior of the alveolar part of the upper jaw; a curvature answered to by a similar one in the incisor teeth and their roots.

In all these respects the Hottentots resemble the Chinese, as also in the less constant character drawn from the height to which the bones of the nose ascend.

In both the vault of the cranium very often projects in the median line. In both we find, in most cases, elongated quadrilateral orbits, which incline outwards.

The projecting form and outward inclination of the angles of the lower jaw are frequently met with both in the Hottentots and in the Chinese. I must, however, admit that in the Chinese the nose is not so flat as it generally appears to be in the Hottentots. Immediately above the pyriform opening the nasal bones are more projecting in the former than in the latter. This difference was perceptible even in the Chinese and Hottentots whom I have seen alive. It follows from this that although the Chinese are in general platyrhinous, they are so in a less degree than the Hottentots.

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* *Decas collectionis*, Göttingen, 1790.

† *Tijdschrift v. nat. Geschied*, iii. p. 143.

‡ *Zur org. Formenlehre*, 1844.

§ *Mém. de l'Acad. de St. Petersbourg*, x. p. 241.

‖ *Ethnolog. Schriften*, 1864.

¶ *Catalogue du Musée Vrolik.*

** *Dissertatie*, Leyden, 1877.

In the second place, the convexity of the facial surface of the upper jaw is met with more frequently in the Hottentots than in the Chinese.

The peculiarity of having the angles of the lower jaw curved outwards, cannot be regarded as a race-character. I have met with it pretty frequently in the Caucasian crania of the Vrolik Museum. It must be noticed, moreover, that it exists principally in the crania of men. The crania of women—Hottentot, Chinese, and Caucasian alike—only show it rarely and in a very feeble degree.

M. de Koning has studied the anomalies of the sutures of the temporal region in the Chinese crania of the Leyden Museum, namely, the frontal apophysis of the squamous portion of the temporal and the sutural bones developed in the squamous suture which is situated towards the frontal bone. Similar relations, to which M. Virchow is inclined to attach an anthropological significance, were altogether wanting in the Hottentot crania which I have had the opportunity of seeing, nor do Messrs. Barnard Davis and Wyman (*loc. cit.*) mention them in the Hottentots examined by them.

In forty-one Caucasian crania in the Vrolik Museum, I have nine times found a sutural bone in the squamous suture, namely, eight times on one side only, and once (in the cranium of an Englishwoman) on both sides. Two of the Caucasian crania were stenocrotaphic. In none have I seen a true frontal apophysis of the squamous portion of the temporal.

The frequency of this sutural bone in the Caucasian crania of the Vrolik Museum is evidently quite a matter of chance. May not the frequency of the frontal apophysis of the squamous portion of the temporal of the Chinese studied by M. de Koning be in the same case?

I must here express my regret that I have not been able to study all that has been written about Hottentot crania. It is therefore very probable that I have neglected some important characters already noticed by other authors.

Van der Hoeven was of opinion that the analogy between the Hottentots and Chinese to which Barrow had called attention, only extended to the colour and the direction of the eyes.*

Although the similarity in colour and general appearance seems to me to be a fact of very great importance, I think that the cranial characters, in spite of certain differences, equally authorizes us to admit a close affinity between the Hottentots and Chinese.

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* *Tijdschr. v. Nat. Geschied,* tome iii. p. 153.

To check the conclusions which I have found it necessary to adopt, it would be important to compare thoroughly the language, manners, customs, religion, legends, &c. of the two peoples. The facts which I have been able to collect on these heads are unfortunately but of little significance.

Dr. Carpenter, one of the few authors who admit the relationship between the Hottentots and the Mongols, having asked Mr. Norris whether there existed any analogy between the languages of the two races, received a reply in the affirmative: 'The affinities of the Hottentot language being rather connected, in his opinion, with the languages of High Asia, although the connecting links are extremely slight.' (Carpenter's *Human Physiology*, 5th Ed. p. 897.)

Prof. Schlegel, whom I have consulted on this subject, advised me not to place too much confidence in so vague an assertion, and said that in his opinion the affinity in question would be very difficult, if not impossible, to demonstrate.

Supposing, however, that there was no relationship between the two languages, it would still be no sufficient reason for denying the affinity between the races. The Chinese and the Japanese, who, in an anthropological sense, are closely allied, speak languages so different that there would be great difficulty in discovering the slightest analogy between them. The Ainos justify the same remark.

Moreover, the language of the Hottentots, in the course of centuries and under the influence of a number of circumstances, may have been considerably modified. It is certain, however, that in Africa it has undergone no considerable alteration, since, as I have already pointed out, it has remained fundamentally different from the languages of the neighbouring peoples.

As I had received from different sources, independent of each other and worthy of belief (among others from the present grand chief of the Korannas, Mossou Ryt Saaibosch), the communication of a legend, according to which the Korannas (and consequently also the other Hottentots) had arrived at the Cape in boats after traversing the sea, the idea struck me that some striking event in the history of the Chinese, or of other Asiatics, had occasioned an emigration. But to the questions which I put on this point to M. Schlegel, the reply was negative.

The Chinese in the fifteenth century only knew the eastern coast of Africa as far as Melinda (Dozy).

We must notice, also, that at a period already far distant, some Chinese, lost at sea, landed on the Isle of Bourbon, where their race is preserved to the present day, fairly pure (there were therefore women amongst them). M. Schlegel writes to me that, according to an oral communication of M. Grandidier, these Chinese refer their arrival in Bourbon to the fifteenth or sixteenth century. A French half-caste, whom I met in the Diamond fields of South Africa, gave the date of their establishment still earlier.

The mythology of the Hottentots leaves us equally in obscurity. Old travellers, Kolbe amongst others, have described with much emphasis the religious ceremonies of the Hottentots. None of these accounts deserves the smallest confidence, any more than those of certain missionaries who believed they had made the same observations.

Le Vaillant, who of all the travellers to the Cape is most worthy of belief, and whose accounts are most exact and most provable, was unable to observe any trace of religion, either in the Korannas or in the Namaquas.

The later researches of M. Bleek on the mythology of the Bosjesmans do not further enlighten us on the subject. The legends and the myths collected by him all relate to the animals of Africa and to the stars of the southern sky. Most, if not all of them, are of very recent date. This is evident, among others, in the myth of the origin of the Moon, which M. Bleek regards—it is difficult to understand why—as among the most ancient. 'The Mantis threw one of her *shoes* at the Moon, which made it red (the Moon) because the red sand of the Bosjesmans' country adhered to the shoe, and cold because the shoe was only made of *leather*. *Thus the Moon is red because she was covered with the red dust of Bushmanland, and cold because it is only leather.*' (*Cape Monthly Magazine*, xi., 109.)

Now I must point out that the ancient Hottentots, although knowing since the sixteenth century how to tan skins, never wore shoes. Further, all the Bosjesmans whom I have seen were barefooted. The only *chaussure* which is found among them of ancient date (and not even generally) consisted of straps rolled round the lower part of the leg. As for shoes, the Bosjesmans knew nothing of them until they came in contact with the Europeans. The legend in question, then, must have been formed afterwards.

The first attempts at painting among the Bosjesmans are probably of an equally recent date. The reproductions which Wood gives of them in his *Natural History of Man*, suggest immediately the idea of badly-executed sketches of naval officers, recognizable among other things by the peculiar form of their hats. Some hunters assured me they had seen, in caves, early representations of animals.

All the Hottentots have a vivid imagination. They speak and sing willingly, but their recitals generally wander far from the truth. It is this which makes me look upon the information collected by M. Bleek in his *Bushman's Researches*, as possessing a very problematical value.

A new indication may be furnished, I think, by their domestic animals. At the time of the discovery of the Cape the Hottentots possessed both sheep and oxen.

Sheep were originally entirely unknown to the Caffres and to the Bechuanas, as also, if I am not mistaken, to the Damaras and to the Ovampo.

The indigenous race of sheep of the Hottentots, which has at present, perhaps, entirely disappeared from the Cape countries, was the sheep with a big tail, identical, apparently, with the *Ovis platyura*. This *Ovis platyura*, from what I have heard from Mr. Horst, comes from the hot parts of Western Asia and the south of Russia, whence it has been imported into certain parts of Africa. The Hottentots were in possession of this sheep before the arrival of the Europeans; had they not brought it with them on leaving Asia? If the identity of the big-tailed sheep of the Cape with the *Ovis platyura* could be placed beyond doubt, it would be, in my opinion, a very important indication as to the question of the origin of the Hottentots.

The possession of this sheep-race proves still more. In the north of the Cape country we do not find any sheep. The middle part, including the northern Transvaal, seems entirely unfit for rearing these animals. Amongst the known causes we can quote the poisonous qualities of the pasturage, the presence of the *tsetsé* fly, and of special pneumonias. It would, therefore, have been difficult, if not impossible, for the Hottentots to move on from the North to the South on the firm soil of the Cape.

Cattle were reared by the Caffres and Bechuanas as well as the Hottentots. As to the Caffres, I believe that they possessed particular breeds of oxen (Zulu and Boeskop races); as to the Hottentots I have not been able to discover anything of the kind.

The Europeans got to know the Hottentots only at the end of the fifteenth century. As I have said already, the population of the Cape was then only thin. According to an estimate founded on the statements of travellers, I believe that the total of Hottentots at that period did not surpass 200,000. This number, which I should even feel inclined to reduce, is certainly only small for a people, which was, for a long series of centuries, in circumstances so favourable to its multiplication.

Moreover, it would be a very strange *lusus naturæ*, that could have produced at the Cape a race so characteristic, so different from all neighbouring people, and showing so much analogy with the Mongolian race.

REVIEWS.

ANIMAL LIFE.*

FEW naturalists can claim to speak with more authority than Prof. Semper. A long residence in those rich tropical Eastern countries, the natural productions of which we know chiefly from the descriptions of hurried travellers, or from the researches of scientific expeditions, familiarized him with the structure and habits of a most varied assemblage of animal forms; and his previous training enabled him to make good use of the unrivalled opportunities of study thus afforded him. Accordingly it is no great wonder that his volume of the 'International Science Series,' lately published, should be unquestionably one of the most interesting contributions to zoological literature that has appeared for years.

Holding the doctrine of the evolution of organic forms as proved, Prof. Semper considers that there has been sufficient theorizing on the subject, and that what we now require is an exact investigation, by observation and experiment, of the processes by which changes are produced in the organism. Thus he says in his Preface:—'The popular cant about "Biogenetic principles and the falsification of Ontogenesis—the laws of inheritance at corresponding periods of life, or the correlation of organs—Ontogeny and Phylogeny—variability and heredity"—is put out of court as useless; for these are merely axiomatic expressions for a sum of identical or correlative phenomena, of which the essential nature is in no way revealed by them;' and it is with the view of indicating the road which he thinks should be taken to furnish the true explanation of these generalized expressions that his present book was written.

Variability, he thinks, of all the properties of the organism 'is that which may first and most easily be traced by exact observation to its efficient causes;' and it is to the phenomena and causes of variation in animals that his book is chiefly devoted. But it has a further limitation. Prof. Semper is of opinion that the action of conditions external to the organism is a much more potent factor in the modification of the latter than is supposed by many naturalists of the so-called Darwinian school, or, in fact, by Mr. Darwin himself, at least in his earlier writings on the origin of species.

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* *The Natural Conditions of Existence as they affect Animal Life.* By Karl Semper. 8vo. London: Kegan Paul & Co. 1881.

From this point of view the question of the variability of organisms is treated in a most thoughtful manner by Prof. Semper, and illustrated by the citation of a multitude of examples from all divisions of the animal kingdom, and in many cases founded on the personal observations of the author.

In the action of external conditions of existence upon animals, Prof. Semper distinguishes transforming and selective influences; but, in his arrangement of his subject, he divides the external agents into those belonging to inorganic or inanimate nature, including under this term the food which, although it may be derived from living organisms, does not become food until after they are dead; and those due to living organisms, and especially to living animals of other species. Both these series include both transforming and selective influences.

Under the former category we have, besides food already mentioned, the influence of light and temperature, that of the condition of the water upon aquatic animals, and of the air upon others, the influence of currents upon the distribution of animals, and some other points; under the second, the action of parasites and hybridization indirectly transforming animals, and the consequences of the competition among animals in its selective influence on the organisms. In connexion with the influence of water in motion, Prof. Semper furnishes his readers with an exposition of his views on the formation of coral reefs, illustrated especially by his own investigations on the Pelew Islands, which, as is well known, have led him, in opposition to the generally received views of Mr. Darwin, to the opinion that here, at any rate, the evidence is in favour of the occurrence of upheaval of the region during the formation of the reef. So far as the Pelew Islands are concerned, there is no doubt the author makes out a very strong case; but whether it is an exceptional one remains to be seen. Under any circumstances, his description of the Pelew reefs will be read with much interest.

Throughout his little book, indeed, the amount of interesting information on the structure and habits of animals that Prof. Semper lays before his readers is very great; and the statements in the text are supplemented by a series of most valuable notes on points of detail, forming an appendix. The book is very freely illustrated with well-executed woodcuts, and is certainly one of the most attractive volumes on natural history that has appeared for several years.

A POLAR RECONNAISSANCE.*

THIS most interesting book is intended by Captain Markham not only as an account of a voyage made by him in company with Sir H. Gore Booth to the seas surrounding Novaya Zemlya, but also as an argument in favour of renewed exploration in the Arctic regions, and as an indication of the direction in which he thinks future attempts to reach the North Pole should be made. In furtherance of his general design he prefaces the description of his own voyage with a historical account of the progress of discovery in the region of Novaya Zemlya, which, brief as it necessarily is, contains an exceedingly interesting record of a long series of most gallant attempts to enlarge the knowledge of the geography of these inhospitable regions.

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* *A Polar Reconnaissance, being the Voyage of the 'Isbjörn' to Novaya Zemlya in* 1879. By Albert H. Markham. 8vo. London: C. Kegan Paul & Co., 1881.

As regards the exploration of the region around the Pole itself, Captain Markham is of opinion that the most hopeful direction for further research is along the west coast of the land discovered by the Austrian expedition under Weyprecht and Payer in 1872, and named by them, in honour of their Emperor, Franz Josef Land. The records of former voyages, and Captain Markham's own experience in the *Isbjörn*, would seem to show that in August and September in ordinary seasons there would be no difficulty in reaching and exploring Franz Josef Land in a steamer; and as the southernmost point of that land is beyond 80° N. lat., it would certainly seem that in this direction we may with little trouble or delay attain a proximity to the Pole which was only reached with considerable expenditure of time and labour in our last expedition through Smith's Sound.

The *Isbjörn*, in which Captain Markham and his companion visited Novaya Zemlya and pushed a considerable distance further towards the north, was a little cutter of 43 tons burthen built for Arctic purposes in 1870, and employed by the Austrian explorers, Weyprecht and Payer, in making a reconnaissance preliminary to their voyage in the *Tegetthof*. The description of the accommodations on board this little craft, and especially of the *désagrémens* caused by the dirty and untidy habits of their Norwegian sailors, is by no means attractive; nevertheless, the boat, small as it was, seems to have been admirably fitted for the purpose, although apparently rather too 'lively' in a rough sea to be quite agreeable even to a captain in the British Navy.

The travellers embarked at Tromsö on May 18th, reached Novaya Zemlya on the 9th June, and remained about the shores of that island until the 5th September. They were prevented from navigating the Kara Sea by the presence of ice and the exaggerated idea of the danger involved in encountering it entertained by the crew of their little vessel, especially two harpooners, who were regarded as *ex officio* authorities on the subject of ice-navigation, and who appear to have been rather pusillanimous when brought into contact with ice in any shape. Accordingly, when the *Isbjörn* quitted the northern extremity of Novaya Zemlya, her course was taken in a north-westerly direction, with the intention of bearing up towards Franz Josef Land, but ice was again met with about 78° N. lat. and the fears of the crew were again excited, although this time apparently with more reason, as Captain Markham himself seems to have come to the conclusion that there was pack-ice in front of them. On the 12th September, in the midst of ice and with foggy and rough weather, the travellers reached their most northern point in 78° 24′ N. lat., or within about 100 miles of the southernmost part of Franz Josef Land; but here the danger of being caught in the ice in so small a vessel and with only a month's provisions on board made a quick retreat the most prudent course that could be adopted, and they sailed in a south-westerly direction to regain Tromsö, where they arrived on the 22nd. Another sailing vessel, the Dutch schooner *Willem Barents*, under the command of Captain de Bruyne, was engaged in an exploration of these seas at the same time as the *Isbjörn*, but was more fortunate, for she met with no ice of consequence on her way to Franz Josef Land, which she sighted on the 7th September.

Captain Markham's narrative of the events of the voyage is very pleasantly given, and as the greater part of the time was passed off the shores of Novaya Zemlya, upon which the travellers landed frequently, we get from him a very good account of the scenery of the islands, which is illustrated by several very well-executed woodcuts. Much attention was paid to the natural history of the districts visited, and Captain Markham not only records his observations upon the habits of various animals, especially some of the sea-birds; but he made considerable collections both of animals and plants which have enabled him to add considerably to our knowledge of the fauna and flora of Novaya Zemlya. Special reports on these collections by several distinguished naturalists are given in the form of appendices at the end of the book, which, from all points of view, must be regarded as an important contribution to the literature of Arctic exploration.

HELMHOLTZ'S LECTURES.*

PROF. HELMHOLTZ'S reputation stands upon a tripod. It rests, first and foremost, upon his originality as a physicist; then upon his mathematical powers; and, thirdly, upon his contributions to physiological science. Rarely has a man of such versatility exhibited the profundity of knowledge which Prof. Helmholtz has reached in each of these pursuits. Whether we view him as physicist, as mathematician, or as physiologist, we are equally constrained to admire the rarity of his genius.

The work which is now before us contains essays bearing upon each of his favourite studies, and therefore, though small, it will appeal to a variety of readers. The mathematician will instinctively open the volume at the lecture 'On the Origin and Significance of Geometrical Axioms;' the medical man will unfailingly turn to the address entitled 'Thought in Medicine;' while the student of physics will natually read the *éloge* on Gustav Magnus, or the lectures 'On the Relation of Optics to Painting,' or the discourse 'On the Origin of the Planetary System.'

But these Lectures are not addressed exclusively, or even mainly, to specialists; they are, as the title indicates, emphatically 'popular.' When Ancient Pistol asks the king, 'Art thou base, common, and *popular?*' he uses the word as a derogatory expression. But these Lectures are popular in the very best sense of the word:—the science is popularized without being vulgarized; the lectures may readily be 'understanded of the people,' while they still retain the true ring of sound science. In fine, they are essays which may be read with relish by every man of culture, whether scientific or not.

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* *Popular Lectures on Scientific Subjects.* By H. Helmholtz, Professor of Physics in the University of Berlin. Translated by E. Atkinson, Ph.D., F.C.S. Second Series. 8vo. London: Longmans, Green, & Co., 1881.

It is to be regretted, however, that some of the lectures published in this volume have grown rather old, and have thus lost the edge of their interest. Thus the opening discourse on Magnus was delivered as far back as ten years ago! Dr. Atkinson, the accomplished translator of the Essays, has wisely introduced considerable modifications into the last lecture, dealing with 'Academic Freedom in German Universities;' a lecture which, in its original form, contained remarks on the Universities of Oxford and Cambridge that could hardly be reproduced at this time in England, and certainly would not reflect the present position of education at those centres. Let us hope that Prof. Helmholtz's second series of Popular Scientific Lectures will be as well received by English readers as were the first.

NATURE'S HYGIENE.*

IT is a general belief that the vicinity of a pine-forest is exceptionally healthy, and of late years the *Eucalyptus* has also been credited with sanitary properties of a very marked character. Mr. Kingzett addressed himself some time ago to the chemistry of the subject, in order to explain, if possible, the hygienic influence of these trees. His researches lead him to attribute their influence to the presence of certain essential oils, which, by their slow oxidation, exert a purifying action upon any malarious exhalations. Under the influence of air and moisture, the volatile oils of the *Eucalyptus* and of the pine are oxidized, yielding peroxide of hydrogen—a powerful disinfectant—and camphoric acid, which is antiseptic. The oil of turpentine has, apparently, a higher oxidizing power than the oil of eucalyptus, and hence pines are especially efficacious in rendering a locality salubrious.

Mr. Kingzett's studies have led him to prepare an artificial substance which he terms 'Sanitas;' but a review of a scientific work must not become a medium for advertizing a new disinfectant. Suffice it to say, then, that Mr. Kingzett's researches in *Nature's Hygiene* are so clearly put before the public in the present work as to be quite intelligible even to those who are not versed in chemical lore.

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* *Nature's Hygiene: A Series of Essays on Popular Scientific Subjects, with special reference to the Chemistry and Hygiene of the Eucalyptus and the Pine.* By C. T. Kingzett, F.C.S. 8vo. London: Baillière, Tindall and Cox. 1880.

PHYSIOLOGICAL CHEMISTRY.*

MEDICAL students have undoubtedly been hitherto at a loss for a handy book of physiological chemistry. True we may point to the fine treatise of Klein, Foster, Burdon-Sanderson, and Brunton; but few indeed are the students who have time to read and digest so elaborate a work. What most students require is a neat and compendious book which will serve as a guide in the physiological laboratory and will give them sufficient grasp of the subject to enable them to meet the examiner. It is not, now-a-days, enough to have 'read up' the subject in a text-book, but the student must show that he has actually seen and handled what he reads about; he must prepare tissues for microscopic examination; he must test the proximate principles of the body; he must demonstrate the chemical composition and the characteristic reactions of the various constituents of the tissues and of the nutritive fluids. How is all this knowledge to be acquired in a limited time? Books on histology there certainly are; but where can the student learn in small compass the pure chemistry of his subject? This is the want which Dr. Ralfe has set himself to supply, and we believe that the little work which he has produced is, in every way, fitted for its purpose. The instructions seem to be clear, concise, and trustworthy; and every student in a physiological laboratory will find it useful to have it at his elbow.

THE CONSTITUTION OF THE EARTH.†

MR. WARD, when a young man of two-and-twenty, favoured the world with a modest essay, in which he enunciated his views on the constitution of the Earth. The leading object of the writer was to show that the Earth had derived its existence from the Sun, and had been, and still was, slowly increasing in size: not by mechanical action, but by a physiological process analogous to the growth of an organic body. Six-and-thirty years have passed since that essay appeared, and science has meanwhile advanced with unexpected rapidity. Nevertheless Mr. Ward believes that the march of science has only strengthened his position. Soon after the publication of his essay there appeared the *Vestiges of Creation*, and at a much later period *The Origin of Species*. But Mr. Ward had forestalled the writers of these works, and had convinced himself of the transmutability of species; only he had his own way of explaining the operations of the laws of development. The present work is but an expansion of the earlier essay. It is not likely that Mr. Ward will secure a large number of adherents to his peculiar view that the Earth is growing larger by a kind of vital action; nor do we think that he will do much to stem the current of scientific scepticism which has disturbed his peace of mind. The astronomer, not less than the geologist, will have many a bone of contention to fight over with Mr. Ward.

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* *Demonstrations in Physiological and Pathological Chemistry; with a Concise Account of the Clinical Examination of Urine.* By Charles Henry Ralfe, M.A., M.D. (Cantab.), F.R.C.P., &c. 8vo. London: David Bogue. 1880.

† *The Constitution of the Earth; being an Interpretation of the Laws of God in Nature, by which the Earth and its organic life have been derived from the Sun by a progressive development.* By Robert Ward. 8vo. London: George Bell and Sons. 1880.

STEAM AND THE STEAM-ENGINE.[*]

ACCORDING to the title-page of the new edition of Dr. Evers's *Steam*, the work has now reached its twenty-sixth thousand. We may therefore take it that in the keen struggle for existence among the many text-books which crowd the market, Dr. Evers's work has shown healthy vitality, and has asserted its right to live and to take rank among our standard manuals. At the time of its first appearance there was no work of its kind—at once comprehensive and cheap—and Dr. Evers supplied a want which had been felt, especially by classes working in connexion with the Science and Art Department. Primarily intended for use in such classes, it by no means servilely follows the Syllabus of the Examinations, and certainly stands above a cram-book for use in preparing for the May ordeal. The new edition has been revised, and has received the benefit of an additional chapter on compound engines.

EXTINCT BRITISH ANIMALS.[†]

MR. HARTING opens the introduction to his treatise on recently extinguished British Mammals in the following words:—'The interest which attaches to the history of extinct British animals can only be equalled by the regret which must be felt by all true naturalists at their disappearance beyond recall from our fauna. It is a curious reflection at the present day, as we pass over some of the wilder parts of the country, that at one time these same moors, and woods, and glens, which we now traverse so securely, were infested to such an extent with ferocious animals, that a journey of any length was, on this account, attended with considerable danger.' It needs the spirit of the true naturalist to regret the change that has taken place.

Either as naturalist or sportsman, however, Mr. Harting revels in the ideas thus conjured up. His imagination brings before him scenes which, to rdinary mortals, may seem unattractive enough, but upon which he dwells vith sentimental yearnings. 'Packs of wolves,' he says, 'which usually ssued forth at night to ravage the herdsman's flocks, were ever ready to ttack the solitary herdsman, or unwary traveller on foot, who might venture o pass within reach of their hiding-places. In the oak woods and amongst he reed-beds which fringed the meres, wild boars lurked . . . . . Many a raveller then had cause to rue the sudden and unexpected rush of some rand old patriarch of the "sownder," who, with gnashing tusks, charged ut upon the invader of his domain, occasionally unhorsing him, and not nfrequently inflicting severe injuries upon his steed.'

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[*] *Steam and the Steam-Engine: Land, Marine, and Locomotive.* By Henry Evers, LL.D. (*Collins' Advanced Science Series*). 8vo. London: W. Collins and Sons. 1880.

[†] *British Animals extinct within Historic Times, with some accounts of British Wild White Cattle.* By James Edward Harting. 8vo. London: Trübner & Co., 1880.

Degenerate Britons of the present day may, perhaps, be glad to compound r the absence of such wild beasts as the wolf, the bear, and the wild boar, y their freedom from the chance of finding any such excitements as the ove when journeying from town to town on foot or on horseback; but the thusiasm that prompts the author of this book to express his regret that e wild beasts, with all their inconvenient habits, have passed away from r country, may serve to give the reader an assurance that no pains have en spared by him in its preparation. It is difficult, as he justly says, to lize the state of things above indicated, 'unless we consider at the same ne the aspect and condition of the country in which these animals lived, d the remarkable physical changes which have since taken place.' Half country, at least, was forest, or wild, uncultivated ground, and in the appearance of this state of things the naturalist can hardly avoid finding ne cause of regret, hundreds of organisms, both animal and vegetable, must ve succumbed to the progress of cultivation and the spread of population, ich have now attained such a pitch that one has to travel a considerable tance from London, at any rate, in order to find a bit of undisturbed land. w different from the condition of things some six or seven centuries ago, en the forests came up almost to the gates of London, and the churches certain cities lighted beacons on their towers to guide belated travellers ough the waste outside.

Five mammals, which have become extinct in Britain within the torical period, are here recorded by Mr. Harting, namely, the Bear, Beaver, the Reindeer, the Wild Boar, and the Wolf. On the last-named mal Mr. Harting contributed a long article to this *Review* some years . It is treated here very much in the same manner, but with consider- e additional information. The Bear, as a British animal, does not seem ave been abundant in the southern parts of the country within historic times; there is no doubt that it existed in England and Wales at least as late as the ldle of the eighth century. In Scotland it seems to have survived till the th century. Its presence in Ireland as a native animal is doubtful, except m fossil evidence. The Beaver, remains of which are not very uncommon peaty soils in the fenlands and elsewhere in England, seems to have sur- ed till the end of the twelfth century in Wales, and to a much later period Scotland. In the latter country there is somewhat doubtful testimony to occurrence as late as the sixteenth century. The historical evidence of existence of the Reindeer in Britain is still more scanty, and rests princi- ly upon a statement in an Icelandic Saga to the effect that the Jarls of kney were in the habit of crossing to Caithness in the summer to hunt this animal and the red deer—a statement the preciseness of which is rendered doubtful by the use in the original Saga of a conjunction of variable meaning, which leaves it uncertain whether the writer was referring to two animals, or using what he thought were two names for the same. The Wild Boar seems to have survived until well on in the seventeenth century.

Besides these animals, which have become absolutely extinct in this country, Mr. Harting has a chapter on the so-called wild white cattle, generally supposed to represent the original wild cattle of these islands (*Bos primigenius*). Like the Aurochs or European Bison, these cattle may fairly be regarded as extinct as wild animals, seeing that their only representatives are to be found preserved in certain parks in various parts of the country.

The subjects here discussed are of great interest; and Mr. Harting has spared no labour in endeavouring to do justice to them. Old deeds, books of all kinds, law reports, and the most miscellaneous sources have been ransacked by him in search of information upon these former denizens of our islands; and the result is that he has brought together, in a most readable form, a mass of very curious information, old and recent, of special interest to the zoologist, but which may be perused with pleasure even by those who are not naturalists.

THE CHRISTIAN KNOWLEDGE SOCIETY.

THE Committee of the Society for Promoting Christian Knowledge seem inclined to hold very broad views as to what may be called 'Christian Knowledge.' Their theory, no doubt, is that the cultivated Christian ought not to be behind other people in general knowledge, and in this we think they are quite right. We have already had occasion to notice one or two popular works on scientific subjects: such as Prof. Duncan's little seaside book, and the late Prof. Ansted's elementary treatise on Minerals; and we have now received from the Society a parcel of books, to which we may call the reader's attention, although some of them have no claim to a strictly scientific character.

This applies more especially to two volumes by Mr. Davenport Adams, entitled *Wrecked Lives, or Men who have failed*, in which the author has given some account of the lives of several more or less prominent or distinguished men, who, like the boy who didn't care, came to a bad or unsatisfactory end. Another work, by the same author, describes the doings of a select band of travellers, commencing with Marco Polo, and winding up with Major Burnaby and Sir Samuel Baker. This little book* will be read with interest; it gives a good popular account of some of the more important journeys made in various parts of the world. Mr. Eden's volume on Africa† gives a good popular history of the progress of discovery on the African continent, embracing the labours of Bruce, Park, and his successors Denham, Clapperton, and Lander, Du Chaillu and Schweinfurth, and finally Livingstone. The book concludes with Livingstone's last expedition. It is illustrated with a small folding map of Africa and some tolerably good woodcuts.

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* *Some Heroes of Travel; or Chapters from the History of Geographical Discovery and Enterprise.* By W. H. Davenport Adams. Sm. 8vo. London, 1880.

† *Africa, seen through its Explorers.* By C. H. Eden. Sm. 8vo. London.

Two other little volumes, although not upon what are generally considered scientific matters, may nevertheless possess considerable interest for the readers of this *Review*. They are treatises upon the two great ancient systems of philosophy,—Stoicism and Epicureanism.* Both these little books appear to be exceedingly well executed, and the subjects are handled in a free and philosophical spirit. We may remark, especially in connexion with these works, where it might have been looked for, the entire absence of any obtrusive Christian pietism. The authors seem throughout to seek to recognize what is good in these ancient philosophies, and to lay before their readers a candid statement of the historical facts.

In Dr. Goodwin's treatise on the *Origin of the World according to Revelation and Science*,† we certainly seem to see some traces here and there of the *odium theologicum*, and we do not think the author has done very much towards clearing up the difficulties of the case. He evidently does not clearly realize what is meant by origin of species by evolution. The key to his idea is that the account of the creation in Genesis is to some extent poetical, but especially moral and didactic, the description of the creation of animals and plants being merely the framework for the picture of the creation of man to which they in a manner lead up.

The first of a series of shilling *Manuals of Elementary Science*‡ is on Electricity, and by Prof. Fleeming Jenkin. It is necessarily a very brief exposition of the principles of the science; but it seems to be very clearly written, and to touch upon all the more important points.

We have kept to the last the most pretentious of the volumes that we have received from the Society; not, however, for the ordinary reason that it is the best, but from directly opposite considerations. It is called a *Natural History of British Fishes*, by the late Frank Buckland,‖ and but for the melancholy circumstances under which it has been produced, we should have felt bound to handle it pretty severely. As a *Natural History of British Fishes* it is lamentably defective, the author's well-known want of scientific knowledge, and ignorance or disregard of what other people have done, being conspicuously shown in nearly every page; and the book may be defined as little more than a pretty lively narrative of Mr. Frank Buckland's experiences in the pursuit of ichthyological knowledge by the light of his own intellectual lanthorn. It contains, however, some interesting details upon fisheries; and the practical appendix on fishponds, the acclimatization of fish, and the artificial breeding of salmon, may prove useful. The account of the salmon is also the best section in the body of the work. The woodcuts with which it is illustrated are for the most part indifferent.

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* *Stoicism*. By the Rev. W. W. Capes.—*Epicureanism*. By William Wallace. Sm. 8vo. London, 1880.

† *The Origin of the World according to Revelation and Science*. A Lecture by Harvey Goodwin, D.D. Sm. 8vo. London, 1880.

‡ *Electricity*. By Fleeming Jenkin. Sm. 8vo. London, 1880.

‖ *Natural History of British Fishes; their Structure, Economic Uses, and Capture by Net and Rod. Cultivation of Fish Ponds. Fish suited for Acclimatisation. Artificial Breeding of Salmon*. By Frank Buckland. 8vo. London, 1881.

PLANT LIFE.*

WE do not know why the author of this little work has thought proper to publish it anonymously. He has certainly no occasion to conceal his name, for the series of chapters on Botanical subjects, which he has here brought together, show a sound knowledge of the science, and very considerable power of communicating that knowledge in a pleasing and interesting manner. The book does not profess to be a systematic treatise on Botany, but a good method runs through the seemingly desultory chapters; and the general facts of the history of plants will be found to be well described in them. The author commences with microscopic plants, and then describes the structure and growth of plants, and the mode of fertilization of flowers. Ferns occupy another chapter, and others are devoted to the lower groups of Cryptogamia. Recent researches are referred to, such as those of Mr. Darwin and others on predatory plants, on the fertilization of Orchids, and on polymorphism. Interspersed with these are good chapters on the folk-lore of plants, on plants and animals, and on plants and planets, the latter an exceedingly amusing and well-written exposition of some of the absurdities of the old astrological herbalists. On the whole we have seldom seen a book better adapted to inspire unscientific readers with taste for the study of a science. With the view probably of assisting those who may be induced by his more popular book to commence botanical investigations, the same author has published some *Easy Lessons in Botany*,† which seem exceedingly well fitted for the above purpose. What 'the requirements of the Revised Code, 1880,' may be we don't know; but the little book is said to be written to fulfil them. Both these books are nicely illustrated with numerous woodcut figures drawn by the author.

MOVEMENTS OF PLANTS.‡

MR. DARWIN in this work investigates and discusses, after his usual thoroughgoing fashion, a series of phenomena of movement displayed lants, to which he gives the general name of 'circumnutation.' This is employed to express the tendency of the different parts of plants in rth, to describe a series of irregular curves, loops, and zig-zags, by their ements successively towards all points of the compass. As we propose ie next number to have an article explanatory of Mr. Darwin's views. shall not attempt to discuss them in the space at our disposal here, experiments recorded are of the most ingenious kind, and carried out the utmost care, and with that attention to all minutiæ which Mr. win so well knows how to bestow upon the most complicated investigas. Hundreds of figures, showing the tracks made by growing plumules radicles, are reproduced in woodcuts, and we think that on inspecting n the reader will be rather surprised to find that Mr. Darwin has been to evolve anything definite from such an apparent chaos.

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* *Plant-life: Popular Papers on the Phenomena of Botany.* With 148 illustrations drawn by the author. Sm. 8vo. London: Marshall Japp & Co. 1881.

† *Easy Lessons in Botany.* By the author of *Plant Life.* Sm. 8vo. London: Marshall Japp & Co. 1881.

‡ *The Power of Movement in Plants.*—By Charles Darwin, LL.D., F.R.S. Assisted by Francis Darwin. 8vo. London: John Murray, 1880.

SCIENTIFIC SUMMARY.

ANTHROPOLOGY.

Quaternary Human Remains at Nice.—On the 21st March some reports upon the occurrence of human remains in an undisturbed deposit at Nice were laid before the French Academy (see *Comptes Rendus* of the above date). M. Desor described the geological structure of the ground, which had at the surface 1¼ metre of vegetable soil, followed by 1·93 M. of tufaceous calcareous mud, overlying about 1 metre of siliceous sand, with intermixed Pliocene and Eocene fossils, beneath which were 2 metres of gravel, more or less conglomerated, surmounting a compact conglomerate. The bones were found in the calcareous deposit at an altitude of from 25 to 30 metres above the bottom of the surrounding valleys. There is no trace of disturbance or irregularity around the cavity from which the remains were extracted, and all the characters of the deposit show that there can be no question of inhumation. The portions of skeleton obtained were found 0·58 M. above the bottom of the deposit. The stratification is in all directions, and would seem to indicate torrential action, so common in quaternary times; the human skeleton was probably conveyed to the position where it was found by a current. The deposit must have been formed at a period when the shore was lower than at present, when the Paillon and the other water-courses of the coast spread over the Tertiary plateaux before they had hollowed out their present beds. The deposit is thus one of the diluvial formations contemporaneous with the erosion of the Tertiary plateaux.

The human remains found, as determined by Dr. Niepce, consist of the following bones:—Part of the lower jaw, including the left and part of the right ramus, and containing the four last molars well preserved. The alveoli of the teeth are vertical, with no trace of prognathism. The left ramus measures 11 centim. from the angle to the symphysis; and the distance between the two branches is 95 millim. The teeth are scarcely at all worn, and the last molar is as large as the rest.

The other bones are a fragment of the middle of the femur, fragments of the left tibia, a fragment of the left humerus, a fragment of the radius, and a fragment probably of the clavicle. From the examination of these portions Dr. Niepce arrives at the conclusion that the bones probably belonged to a small person not less than thirty years old, probably a woman.

M. de Quatrefages goes into the question of race, for the determination of which the materials do not seem very sufficient. He finds, however, that e jaw strikingly resembles that found in the caves of Engihoul near Liége 1860, which, from additional evidence was referred by M. Hamy to the ce of Cro-Magnon, and this identification would lead to the Nice jaw being ferred to the same race, along with the skeletons obtained by M. Rivière ar Mentone. M. de Quatrefages finds this identification supported by two agments of bone which he refers to the right femur, and which strikingly resent the strong longitudinal projection (*linea aspera*) which is characteristic f the men of Cro-Magnon. This race consequently lived in the Quaternary eriod both on the shores of Nice and among the mountains of Périgord.

ASTRONOMY.

The real Libration of the Moon.—It has long been suspected that from its slightly ellipsoidal figure, the Moon undergoes a real libration, or slight periodical inequality, in its otherwise uniform rotation on its axis. Several attempts have been made to determine the amount of this real libration, but without any great success, though it is known that it must follow certain well-ascertained theoretical laws. Indeed, the theory of gravitation enables us to calculate the theory of this real libration with all desired accuracy, it only remains for observation to determine what is its actual maximum amount; for this depending on the actual figure of the Moon is outside the domain of theory, and appertains strictly to observation.

Lately, Herr Dr. Hartwig, of the Strassburg Observatory, has made an important addition to our knowledge of this subject by an elaborate memoir entitled, *Beitrag zur Bestimmung der Physischen Libration des Mondes.* He has employed, as the foundation of his investigation, forty-two measures, by means of the Strassburg heliometer, of the distance of the crater Mosting A, from seven points in the limb of the Moon. These measures Herr Hartwig proceeds to reduce in practically the same manner as employed by Herr Wichmann in his famous investigation of the year 1847, using exactly the same theoretical basis. The main results obtained by Herr Hartwig, and those previously obtained by Herr Wichmann, are appended:—

		Wichmann.		Hartwig.
Latitude of Mosting A .	. =	$-3^\circ\ 10'\ 21'' \pm\ 11''$	=	$-3^\circ\ 10'\ 55'' \pm\ 24''$
Longitude of Mosting A	. =	$-5\ 10\ 57 \pm\ 25$	=	$-5\ 13\ 23 \pm\ 89$
Inclination of the lunar equator to the ecliptic .	. =	$1\ 36\ 34 \pm 113$	=	$1\ 39\ \ 9 \pm 250$

So far the results are not very discordant, and the small probable errors indicate the superior trustworthiness of Herr Hartwig's results. The effects for the real libration may be written as follows:—

Real libration in latitude . = $+\ 17''\sin\{13^\circ{\cdot}188\,T + 80^\circ\}$ according to Wichmann.

= $+\,295\sin\{13{\cdot}188\,T + 80\}$ according to Hartwig.

Real libration in longitude = $-17'' \sin (0°·4807T)$
$-100 \sin g - 24'' \sin \alpha$, according to Wi-
mann.
$-41 \sin (0°·2807T + 90°)$
$-28 \sin g - 37'' \sin \alpha$, according to Ha-
wig.*

It will be seen that these results are very far from being as accordant as they ought to be, and show that there have been grave systematic errors in one, or both, of the two series of observations or reductions. It is much to be desired that a reduction should be made of a great number of observations made by Herr Schlüter in 1841–44, and it would be desirable to have Herr Hartwig's results reduced with values for the arguments derived from his own observations, and not from those of Wichmann.

Prof. Pritchard, of the Oxford Observatory, is also reducing a number of measures of photographs of the Moon, with the view of determining the real libration. His results are not yet published, but he has stated that they are in accord with those found by Wichmann. In a recent communication to the Royal Astronomical Society, Prof. Pritchard speaks rather despondently of the prospects of determining the actual amount of this real libration. Quoting from an account of his remarks at the Society (Observatory, February 1881), he says: "We must accept this—that these measures and these calculations, though beyond all doubt they show that there really is a lunar physical libration, and that it is somewhere between these numbers, yet you will never get it within 20 or 30 or 40 seconds." But there are far superior methods for determining this real libration than have ever been employed as yet; and so far from accepting the gloomy view taken by Prof. Pritchard, it is probable that astronomers will look to one of these improved methods to reduce the uncertainty to far smaller limit than supposed by Prof. Pritchard. It may be here mentioned that 20 to 40 seconds of selenographical longitude corresponds at the mean distance of the Moon to only one to two tenths of a second of arc; a small enough quantity.

The Diameter of Mars.—Lately (*Monthly Notices R.A.S.* Nov. 1880) Mr. Downing has determined, from some five hundred measures with the Greenwich Transit Circle, the mean diameter of the planet *Mars*, which he finds to be—

$$= 9''·387 \pm 0''·107$$

He also finds that there is a constant correction required for irradiation, which is equal to—

$$= + 2''·369 \pm 0''·175$$

As Mr. Downing points out, the correction is unusually large, that for the Washington 4-inch Mural Circle being only 1″·192.

Mr. Stone, F.R.S., has also lately made a communication to the Astronomical Society on the same subject. He finds that different observers have a considerable personality in observing the diameter of the planets, some making it systematically larger than others. Thus Mr. Ellis's personal equation amounted to $+ 1''{\cdot}10$, whereas Mr. Dunkin's was $- 0''{\cdot}68$, so that Mr. Ellis systematically makes the diameter of *Mars* $1''{\cdot}78$ larger than Mr. Dunkin. A further result was also ascertained, namely, that the diameter was systematically made too large when the planet is at a considerable distance from the Earth. Lastly, Mr. Stone considers that the large irradiation constant obtained by Mr. Downing is fictitious to a certain extent, and due to other causes.

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* In these formulæ, T = the number of mean solar days for January 1, 1845; g denotes the mean anomaly of the Sun; and α, the mean anomaly of the Moon.

The Diameter of Vesta.—Last year, from a numerous set of measures, Prof. Tacchini of Rome determined the apparent diameter of this minor planet to be—

$$= 1''{\cdot}706 \pm 0''{\cdot}09.$$

Since then another set of measures has been obtained by his colleague, Prof. Millosevich, who finds the diameter to be—

$$= 1''{\cdot}655 \pm 0''{\cdot}09.$$

These results, freed from the effect of irradiation, would give about 800 miles for the diameter of this planet.

Jupiter.—Further interesting observations have been made by different observers of the changes which are taking place in the cloud strata of this giant planet. The white spots on the equatorial belt continue to remain visible, but are becoming more irregular in form and dimensions; their edges, too, are becoming softer and less sharply defined. They continue to move much faster than the great red spot, which still continues visible, but has lost much of the vividness of its tint; and Mr. Denning has watched one gain a whole revolution of the planet on the red spot. The band of dark irregular spots on the northern equatorial belt continued to be visible during the winter, but they have changed very considerably in form and appearance, rendering it difficult to accurately determine the period of their rotation. They seem now to move faster than the white spots, though originally Schmidt and some other observers considered their motion to be slower. The greyish belt north of this belt of blackish spots has grown thicker and darker of late, and still further north there are signs of a new belt. Mr. W. F. Denning thus sums up the results of his winter observations (*Observatory*, March 1881):

'It is to be noted that the recent observations of this planet have revealed, in the clearest manner possible, a quadruple series of spot-motions. There is the red spot with its period of $9^{h}\ 55^{m}\ 34^{s}$; the short, dusky streaks (south on the red spot in the southern hemisphere) with their approximate line of $9^{h}\ 55\frac{1}{4}^{m}$, the bright spots on the equator with $9^{h}\ 50\frac{1}{4}^{m}$, and the dark, irregular spots ranged along the belt north of the equator with $9^{h}\ 48^{m}$. Further observations may reveal other phenomena of equal importance; and it is certain that the time has come when this planet will be subject to the constant and critical examination which the marvellous variations in his appearance so obviously demand.'

M. Bredichin is of the opinion that all the recent phenomena presented by the planet *Jupiter* can be explained by supposing that there is an elevated equatorial belt to the planet, and that there is more heat radiated from the southern hemisphere of the planet than from the northern.

Lately an interesting investigation has been published by Herr Harzer, giving the results of his investigation of the perturbing action of this giant planet, *Jupiter*, on the motion of Brorsen's comet of 1846, on the occasion of the very close approach of the comet to *Jupiter* in May 1842. Herr Harzer has ably calculated the great changes in the orbit of the comet produced by the attraction of this giant planet, the principal being a change in the mean anomaly of nearly two degrees in the vectorial angle or eccentricity of a degree, and in the inclination of about two degrees. He also calculates the form of the orbit in which the comet must have moved prior to its close approach to *Jupiter*, and shows that the elements resemble those of a comet discovered by Messier in 1798. He does not think it likely, however, that the two comets are the same. Herr Harzer thinks that there is reason to believe that the orbit of the comet would have suffered similar great changes in 1760, and may undergo similar changes in its near approach in 1937.

On November 20, 1880, Mr. J. Birmingham observed the star B D + 2°, 97 quite close to the planet *Jupiter*, being distant only by $4''\cdot05$, and giving to the planet all the appearance of having five satellites. The light of the star was, however, very different from that of the satellites; and, though it is a 7·7th magnitude star, it shone only like a 10th magnitude star, owing to its proximity to the bright planet.

Swift's Comet = Comet e, 1880.—The later observations which have been made of this comet have seemed to materially alter the earlier impression about its orbit. Instead of having a period of eleven years, it seems that there can be no doubt that its period is really only half of this, or about five and a half years; but owing to the position of its orbit the comet is invisible at every other return to perihelion. The latest and best orbit seems to be that by Mr. Winslow Upton of Washington. He finds as follows:—

Epoch 1880, Oct. 25·5, Washington mean time.

$$1880\begin{cases} \mathrm{M} = 357^\circ\ 48'\ 49''\!\cdot3 = \text{Mean Anomaly at Epoch.} \\ ☊ = 296\ 41\ 55\cdot4 = \text{Longitude of Ascending Node.} \\ \mathrm{W} = 106\ 18\ 13\cdot8 = \text{Distance of perihelion for Ascending Node.} \\ i = 5\ 31\ \ 3\cdot5 = \text{Inclination of orbit.} \end{cases}$$

$e = 0\cdot67594$ = Eccentricity.
$a = 3\cdot29942$ = Semi-major axis.
$\mu = 592''\cdot0373$ = Mean Motion.

From these figures we learn that the comet passed through its perihelion on November 7·79433 Washington mean time, and has a period of 2189·1 days, or only 2·4 days short of six years. This result is in close accord with that calculated by Prof. Frisby from less perfect data. The period of this comet is so nearly equal to half that of the planet *Jupiter*, and its orbit approaches so close to that planet, at a time when that planet is not far distant, that the comet must undergo considerable perturbation in its motion.

Pechüle's Comet = Comet f, 1880.—On Dec. 16, 1880, Herr Pechüle discovered a comet not far from the place of Hartwig's comet. It was small, and at the time of its discovery pretty bright. It soon grew faint, however. According to Prof. Young this comet had two tails, the upper and brighter one was directed towards the Sun, and about 40′ in length; the other, or fainter, tail was only about two-thirds as long. They were too faint to be seen after the 22nd. From the observations Mr. C. S. Chandler has computed an orbit. The elements he obtained were:—

T = 1880, Nov. 9·4087, Washington Mean Time.

$\lambda = 263^\circ\ 0'\ 13''$ Longitude of Perihelion.
$☊ = 249\ 38\ 44$ Longitude of Ascending Node.
$i = 60\ 41\ 24$ Inclination.
$\log q = 9{\cdot}830884$ Log of Perihelion distance.
Motion direct.

Mr. Chandler remarks, 'The orbit of this comet presents a curious general resemblance to that of 1807, memorable from the elaborate investigation by Bessel, whose results indicated a period of 1483 years, and could not be reasonably satisfied with a period of less than 700 years.'

A New Suspected Extension of the Milky Way.—An interesting account has been published by Mr. Arthur Searle, one of the assistant astronomers at the Harvard College Observatory, U.S.:—

'During the last five years I have become convinced by repeated observations that a very faint, but permanent band of light extends from *Aquila* to the *Pleiades*, passing through *Aquarius* and the southern part of *Pisces.* Since a considerable part of its course lies near the ecliptic, it may interfere to an appreciable extent with observation of the Zodiacal Light, and may be worth mentioning on this account. . . . I have consulted several works likely to contain information on similar subjects without finding any notice of it, and its presence seems not to have been generally recognized, if at all. Other observers here have seen parts of it favourably situated for observation at the time when pointed out to them; but fuller and more independent observations are of course required to furnish satisfactory evidence of its existence. As I see it, its width is about 5°, and a line drawn along the middle of the band will begin between α and δ *Aquilæ*, and pass between α and β *Aquarii*, nearly through χ *Aquarii;* thence crossing the ecliptic it will pass near 27 *Piscium* and ν *Piscium*, and will end after recrossing the ecliptic in the faint extension of the Milky Way towards the *Pleiades*. The colour of this luminous band seems to me whitish, not yellowish like the brighter parts of the Zodiacal Light. . . . If other observers should concur in my opinions with regard to the existence and course of this luminous band, it will be a question of some interest whether telescopic stars are unusually abundant along it. This would of course afford the simplest explanation of any phenomenon of the kind.'—*Ast. Nach.*, No. 2358.

Parallax of α and β Centauri.—Herr C. W. Moesta has lately carefully reduced the great number of observations of these stars made at Santiago, in Chili, during the years 1860–1864. From his results he deduces a parallax for α_2 *Centauri* of $+\ 0''{\cdot}579$, and for β *Centauri* of $0''{\cdot}2096$, the difference or relative parallax of the stars being $0''{\cdot}369$, which is somewhat less than that found from the observations made at the Cape.

Parallax of the Star Piazzi III. 242.—Nearly twenty years ago attention was directed by Otto Struve to the desirability of determining the parallax of this star as it forms a wide binary pair with its neighbour, 50 *Persei*, some 15′ distant, and is itself a binary double. Dr. Ball has lately taken up this investigation, but with disappointing results, as the parallax comes out with a very small negative quantity. It is obvious, therefore, that this star has no sensible parallax. It would really seem worth ascertaining whether its binary neighbour, 50 *Persei*, also gave a similar result.

BOTANY.

The Markings of Diatoms.—M. W. Pring has sent us a copy of a paper communicated by him to the *Société Belge de Microscopie* (*Mem.* tome vii.), containing descriptions of some sections of Diatoms. He obtained his sections by making thin slices of a diatomaceous rock from Nykjobing, in Jutland, and his observations relate chiefly to three species, namely, *Coscinodiscus oculus-iridis*, *C. excentricus*, and *Trinacria regina.* In the first and third of these he finds that the markings of the valves are true alveoli traversing the thickness of the outer layer, and terminating against the inner layer, which is also perforated by smaller apertures.

Elongated Spiral Cells in the Leaves of Crinum.—M. Trécul finds that in the leaves of some forms of *Crinum*, especially *C. americanum*, there are large spiral cells with the aspect of spiral vessels, either isolated in the parenchyma, or collected into more or less numerous groups. The blade of the leaf shows numerous parallel fibrovascular bundles, which become thicker in the direction of the thickness of the leaf towards the middle of the blade; between them are vacant spaces formed by the destruction of the parenchyma, but interrupted by transverse dissepiments of parenchyma uniting the neighbouring bundles. The spiral or tracheiform cells described by M. Trécul, occur in all parts of the parenchyma of the leaf, but nowhere else in the plant. They attain a considerable length, but in this respect vary greatly. M. Trécul indicates a range of length of from 0·50 to 13·40 millim., in the same species. Two of them were observed to be forked. The number of spiral cells is much greater in *Crinum americanum* than in *C. taïtense:* in fact, these two species may be distinguished by the characters furnished by these cells. *C. africanum* comes nearer to the American species. M. Trécul suggests the question whether the plants presenting the above-mentioned anatomical character, which is not shown by the other *Crina*, are to be regarded as having the same specific origin. If they had a common origin they have undergone considerable modifications; the Tahitian plant, especially, differing very widely from the American. On the other hand, *C. taïtense* being identified by Herbert and Kunth with Rob. Brown's *C. pedunculatum*, which they regard as the first variety of *C. australe*, and therefore allied to *C. rubricaule*, *exaltatum*, and *canaliculatum*, the three other varieties of *C. australe*, it would be interesting to ascertain if all these forms possess the same character of the presence of spiral cells in the parenchyma of the leaves.—*Comptes Rendus*, 4 *February and* 7 *March*, 1881.

GEOLOGY AND PALÆONTOLOGY.

South African Triassic Reptiles.—In a paper read before the Geological Society in April last, and since published in the Quarterly Journal of the Society (Vol. xxxvi. p. 414), Prof. Owen described the remains of a reptile of his order Anomodontia, from the trias of Graaf Reinet, in South Africa, which he considered to show strong resemblances to the lower forms of the *Ma*[illegible] fossils consisted of some thoracic vertebræ, with portions of ribs, a sternal bone, a scapula, and a right humerus, found imbedded in one mass of rock, and of a femur and phalanges, and a pelvis in another mass. With the exception of the pelvis, Prof. Owen described these bones in detail. The vertebræ agree most nearly with those of *Dicynodon*, and *Oudenodon*. The supposed sternal bone is of a rounded hexagonal form, and is regarded by Prof. Owen as the anterior bone of the sternum proper, which is usually unossified in recent lizards, but well ossified in *Ornithorhynchus*. The scapula also presents resemblances to that bone in *Ornithorhynchus*. The humerus in its general proportions, and especially in the great development of its ridges, was also shown to resemble the same bone in the Monotremes. The ungual phalanges were described as broad and obtuse, probably constructed to bear claws adapted for digging, as in *Echidna;* the femur also resembles that of the last-named animal.

Prof. Owen remarked upon these approximations to the Monotrematous Mammalia, in allusion to which he proposed the name of *Platypodosaurus robustus* for this animal, the humerus of which was 10½ inches long and nearly 6 inches broad at the distal end. He also alluded to the interesting problems opened up by the study of these South-African reptiles in connexion with their possible relationships to the low implacental Mammalia of New Guinea, Australia, and Tasmania.

Subsequently the pelvis was freed from the matrix, and Prof. Owen communicated a description of this part of the skeleton to the Geological Society (9th March, 1881). The fossil includes the sacrum, the right 'os innominatum,' and a great part of the left ilium. There are five sacral vertebræ, which Prof. Owen believes to be the total number in *Platypodosaurus*. The neural canal of the last lumbar vertebra is eight lines in diameter, and of the first sacral nine lines, diminishing to six lines in the fifth, and indicating an expansion of the myelon in the sacral region, which is in accordance with the great development of the hind limbs. The sacral vertebræ increase in width to the third; the fourth has the widest centrum. The coalescence of the vertebræ justifies the consideration of the mass, as in Mammalia, as one bone or 'sacrum,' which may be regarded as approaching in shape that of the Megatherioid Mammals, although including fewer vertebræ. Its length is 7½ inches; its greatest breadth, at the third vertebra, 5½ inches. The ilium forms the anterior and dorsal walls of the acetabulum, the posterior and postero-ventral walls of which are formed by the ischium and pubis. The diameter of its outlet is 3 inches, the depth of the cavity 1½ inch, and at its bottom is a fossa 1⅓ inch broad. The foramen is subcircular, 1 inch in diameter. The ventral wall of the pelvic outlet is chiefly formed by the pubis; it is a plate of bone 6 inches broad, concave externally, convex towards the pelvic cavity. The subacetabular border is 7–8 lines thick; it shows no indication of a pectineal process, or of a prominence for the support of a marsupial bone. Prof. Owen remarks that of all examples of pelvic structure in extinct Reptilia this departs furthest from any modification known in existing types, and makes the nearest approach to the Mammalian pelvis. This is shown especially by the number of sacral vertebræ and their breadth, by the breadth of the iliac bones, and by the extent of confluence of the expanded ischia and pubes.

At the same *meeting* Prof. Owen described another new South African reptile from the Trias of Gough, in the Karoo District of South Africa, which he also considered to show strong tendencies towards the Mammalia; but this species he refers to the Theriodont Reptiles, and hence its approximation to the Mammalia would seem to lead in the direction of the Carnivorous Marsupials.

This new type, described by Prof. Owen under the name of *Ælurosaurus felinus*, is represented by the skull with the lower jaw, but with the post-orbital part broken away. There is a single nasal opening (mononarial); the alveolar border of the upper jaw is slightly sinuous, concave above the incisors, convex above the canines and molars, and then straight to beneath the orbits. The alveolar border of the mandible is concealed by the overlapping teeth of the upper jaw; its symphysis is deep, slanting backward, and destitute of any trace of suture; the length of the mandible is 3¼ inches, which was probably the length of the skull. The incisors are $\frac{5-5}{5-5}$, and the molars probably $\frac{5-5}{5-5}$ or $\frac{6-6}{6-6}$, all more or less laniariform. The length of the exserted crown of the upper canine is 12 millims.; the root of the left upper canine was found to be twice this length, extending upwards and backwards, slightly expanded, and then a little narrowed to the open end of the pulp-cavity. There is no trace of a successional canine; but the condition of the pulp-cavity and petrified pulp would seem to indicate renewal of the working part of the canine by continuous growth. The author infers that the animal was monophyodont. *Ælurosaurus* was said to be most nearly allied to *Lycosaurus*, but its incisor formula is Dasyurine.

With regard to the characters of the Theriodontia, the author remarked that we may now add to those given in his 'Catalogue of South African fossil Reptiles,' that the humerus is perforated by an entepicondylar foramen and the dentition monophyodont.

Some of the opinions expressed by Prof. Owen with regard to these Reptiles, especially as to their Mammalian tendency, and the distinctive characters of the order Theriodontia, met with some objections from Mr. Hulke and Prof. Seeley, but the facts adduced are certainly of much interest.

Batrachians and Reptiles.—Prof. Cope has some remarks (*Amer. Nat.*, August, 1880) upon his genus *Cricotus*, founded upon specimens obtained from a shale of Triassic or Permian age in Illinois, and distinguished from the rest of the Stegocephali (Labyrinthodonts) by the complete development of the centra and intercentra of the vertebræ, both of which form vertebral bodies, and, in pairs, support single neural arches. No such character has been detected in the recognized divisions of the Stegocephali; and further knowledge of the structure of the genus shows that it is the type of a distinct division of that group, which Prof. Cope defines as follows:—'Centra and intercentra subequally developed as vertebral bodies, a single neural arch supported by one of each, forming a double body. Chevron bones supported only by intercentra. Basioccipital vertebral articulation cuplike, connected with the first vertebra by an undivided discoid intercentrum.' Thus the peculiarity of the vertebral column in general is continued into the articulation of the head; and, instead of the complex atlas of the Ganocephali, the [illegible]le body connecting occipital condyle and first vertebra. In all probability, this single body represents *the single occipital condyle of the Reptilian skull*, a part which remains cartilaginous in the Lizard long after the basioccipital is ossified, and is a distinct element. The structure of *Cricotus* shows that it is a connate intercentrum. Prof. Cope says:—'We have now removed the last difficulty in the way of the proposition that the Reptilia are derivations of the Batrachia, viz., the difference in the cranio-vertebral articulation. But the former have not been derived from the Labyrinthodontia, as has been suggested, nor from the Ganocephala, but from the Embolomera, as I call the new order or sub-order. The order of Reptiles, which stands next to it, is, of course, the Theromorpha, which presents so many Batrachian characters, including intercentra.' The genus *Diplovertobron*, described by Fritsch from the Permian gas-coal of Bohemia, is believed by Cope to belong to the same group as *Cricotus*.

Geology of the Cape Verde Islands.—Dr. C. Dölter gives a general account of the geology of the Cape Verde Islands in a letter to Prof. Von Hauer (*Verhandl. k. k. geol. Reichsanst.* 15 February, 1881). He says the group of of islands, consisting of two separate clusters, is of volcanic origin; but in places there are also sedimentary rocks, especially limestone, as on the islands of Mayo and Bravao, which, with Santiago and the still active volcano Fogo, form the southern cluster. The unfossiliferous, dense, reddish limestones of Mayo, greatly remind one of the marbles of Trent. It would be difficult to determine their age, and for this purpose a study of the formations on the African continent would be necessary. The island of Santiago, the largest of the Archipelago, represents the remains of a very large volcano, of which the crater is still partially preserved in the Pico d'Antonio, a peak of 2450 metres in height. The great crater of the Pico d'Antonio has formed the whole island, and furnished an enormous number of lava-streams, separated by strata of tuff and rapilli. Veins are rare, and of subordinate importance. In the vicinity of the centre of eruption tuffs and breccias predominate. Besides this great volcano, there are on the margins a dozen of smaller, secondary ones, from 200 to 400 metres in height. The products of the volcano are rocks which may be characterized as andesites, olivine-basalts, and phonoliths, although, of course, their precise composition can only be ascertained by careful examination. As inclusions in the volcanic rocks, there are lumps of limestone converted into marble, and containing materials like serpentime and chlorite, and also phyllite, mica-schist, diorite, diabase, &c. The marbles are the most interesting of these, as such contact formations have hitherto rarely been observed in recent volcanoes.

Of the northern group Dr. Dölter has only examined the volcano of San Vicenti, a great volcano the former crater of which forms the harbour of the island. It consists chiefly of lava-streams, which fall towards the sea uniformly at a gentle inclination. Between them are masses of tuff of subordinate importance, with numerous veins. The margin of the crater has an elevation of about 1200 metres. In the midst of the crater Dr. Dölter found, to his great surprise, masses of dioritic and diabase-like rocks from two to three kilometres in length and breadth, some of them resembling hypersthenite; they were penetrated by veins of basalt and andesite, the rocks forming the volcano, and overtopped by lava-streams. Dr. Dölter [illegible] it probable that in these we have masses of the ancient continent, th of which seems to be proved by the occurrence of masses of schist in the limestone.

Ancient Eruptive Rocks of the Puy-de-Dôme.—M. A. Julien has communicated to the French Academy (*Comptes Rendus*, 28th March, 1881) some observations on the ancient eruptive rocks of the great plateau which bears the more modern volcanic formations of the Puy-de-Dôme. His statement will probably be interesting to travellers in the Auvergne who pay attention to geology. The rocks found are as follows:—Porphyroid granite, ordinary granite with grains of moderate size, leptynite (granulite of M. Lévy), pegmatite with tourmaline and garnets, amphibolic rocks, diorite, amphibolite, and amphibolic petrosilex. The porphyroid granite forms vast expansions, but all the other rocks are in the form of veins, which are very numerous and distinctly marked. The veins of leptynite and pegmatite have a general north and south direction, with slight deviations to the east and west. The veins of amphibolic rocks, on the contrary, generally run W.N.W.

The order of appearance of these rocks was as follows:—First came outflows of porphyroid granite, which is the most ancient granite of the region; then granite with moderate-sized grains in strong veins in the porphyroid granite; then the veins of diorite. During the emission of the latter, amphibolic granites were injected between Aydat and Phialeix, and these again were traversed by veins of rose-coloured and green amphibolic petrosilex. Innumerable veins of leptynite afterwards appeared, and the pegmatites concluded the series of eruptive phenomena. The last two rocks are always quite distinct.

The author states that all these relations are recognizable with the greatest clearness in many parts of this magnificent plateau; but he indicates certain points which he thinks of the most interest.

1. At the Côtes de Ceyrat, along the road which ascends the flanks of the granite cliff to Berzet, the porphyroid granite contains enormous blocks of Cambrian schists. Very distinct veins of ordinary granite, some of them several metres thick, traverse the porphyroid granite. One of them in its course traverses one of the enclosed blocks. Veins of leptynite traverse both granites, and one of them also cuts through the same block of schist already traversed by the ordinary granite.

2. In the quadrilateral included between Theddes, Chadrat, Saint-Genès, Champanelle, and Berzet, the porphyroid granite encloses hundreds of Cambrian fragments, into which it is also injected in branching and anastomosing threads and veins penetrating the fissures of the blocks. The granite must therefore have been extremely fluid at the time of its production. There is no trace of metamorphism; innumerable N. and S. veins of leptynite and pegmatite traverse the whole system.

3. Near Recolène, at 100 metres in front of the village, a magnificent vein of diorite enclosed in Cambrian quartzite, is distinctly cut through by a vein of leptynite 20 centimetres thick.

4. Between Santeyras and Aydat, on the margin of the lake, there is on the road, 100 metres from Santeyras, a thick vein of diorite running N. 50° W. traversing the porphyroid granite and a large included mass of schist. This is in its turn cut by a vein of tourmaliniferous pegmatite 20 centimetres in thickness.

5. Near the last house in the village of Theddes a vein of leptynite, 30 centimetres thick, is cut nearly at right angles by a vein of pegmatite with tourmaline of about equal size.

The formation of all these rocks is considered by the author to have taken place during the Silurian epoch.

PHYSICS.

A Note on the Determination of the Magnetic Inclination in the Azores is communicated to the Proceedings of the Royal Society by Dr. Thorpe. He notes that except a series of similar observations made by the officers of the *Challenger* in 1873, none have been made since Captain Vidal's survey in 1843. Magnetic observing is difficult in these islands, from the intensely volcanic nature of the strata. The dip-circle used was lent from Owens College, Manchester. In the island of St. Michael the mean dip was 62° 40′·2 N., against 63° 56′·8 N. of the *Challenger*. In Terceira it was 64° 10′·3, and in Fayal 63° 38′·5.

The Thermo-electric behaviour of Aqueous Solutions, with Platinum Electrodes, has been further studied by Dr. Gore, in continuation of his memoir, already abstracted in this Summary. To prevent suspicion of error from chemical action upon the mercury electrodes therein used, coiled ribbons of sheet platinum were substituted for mercury, all other parts of the apparatus remaining exactly similar to those employed in the former experiments. They were heated to redness and thoroughly washed. Precisely similar liquids were used as in the first researches, none of them acting chemically on platinum. These were boiled for half-an-hour to expel dissolved air. At 180° Fahr. cyanide of potassium made hot platinum 11·0 positive; whereas the same couple, with sulphuric acid 1 in 40, rendered it 4·25 negative. Between these extremes is a list of thirty-four other substances. This is compared with the former series, and the differences between the results are only in one or two cases important. The chief conclusion arrived at is that the currents previously obtained with mercury are really due to heat, and not to minute amounts of chemical action.

The same observer also contributes memoirs on the *Influence of Voltaic Currents on the Diffusion of Liquids* and on *Electric Osmose*. In the former case the phenomena are very complex, consisting of a mixture of physical and chemical effects, chiefly due to electrolytic changes, to differences of specific gravity, to ordinary liquid diffusion, to electrolytic transfer, and to heat of conduction-resistance. In the latter instance the experiments were similar to that made by Porrett. A vessel of thick glass divided vertically into two equal parts, had a diaphragm of biscuit porcelain about 1·5 millim. thick between its two cavities. The cell was held together by screw clamps. The electrodes were of sheet platinum, the current from several Grove's pint-cells in single series, always in the same direction. In sixty-eight experiments osmose occurred in all but one—a saturated solution of potassic cyanide. It was in the same direction as the electric current, with one exception, that, namely, of bromide of barium in absolute alcohol. This single fact quite invalidates the conclusion that the direction of flow is independent of chemical composition and molecular structure of the liquid. It would appear, however, that this direction depends 'much more frequently upon the direction of the electric current than upon the internal architecture of the liquid.'

A paper complementary to this, by the same distinguished physicist, considers the *Electric currents caused by liquid diffusion and Osmose.* It states that other observers have already obtained electric currents by the contact of two liquids—Nobili the first. His arrangements consisted of a series of four glass cups, each containing an electrolyte, the liquids in the two terminal vessels being similar, with platinum electrodes; a second and third kind of liquid being in the two intermediate cups. The solutions were connected by liquids similar to those in the cups contained in glass syphons, with turned-up capillary ends. Fechner, Wild, L. Schmidt, and Wullner, all attacked the same problem in various ways. To ascertain whether difference of facility in diffusion, caused by the action of gravity upon two portions of of solution of different degrees of concentration and of specific gravity would produce a current, twenty-five small glass tumblers were taken, each alternate one containing liquid of a different degree of concentration. Potassic nitrate was the salt employed. Platinum wire electrodes completed the circuit. The liquids in the vessels were connected by means of inverted bent tubes half an inch in diameter, alternately filled with the two solutions. Where the liquids came in contact at the end of each of the tubes a wet septum of parchment paper was secured. On interposing a galvanometer a feeble current was obtained, not due to differences in the electrodes. Its direction was downwards, through the septa and surfaces of contact. With sulphate of copper and sulphuric acid, a stronger current of similar direction was obtained. Four other experiments, somewhat varied in their conditions, produced a much stronger current, in a reverse direction, from the strong solution upwards through the diaphragm into the weak one. The difference of osmose, through a porous partition, was opposite in direction to that produced by difference of diffusion.

The phenomenon of Regelation, originally discovered by Faraday in 1850, and extended in its physical bearings to explain glacier motion by Tyndall, has been recently made the subject of a memoir in the *Annales de Chemie et de Physique*, by Mons. W. Spring, Professor of the University of Liége. He adverts to the more recent researches of Helmholtz, Bottomley, and especially of Tresca, on the viscosity of solid bodies, but is of opinion that we have not yet attained a satisfactory solution of the question. James Thomson and Clausius have given mathematical expression to the physical laws involved in the phenomenon, the general cases of which have been verified experimentally by Bunsen. But two substances still form exceptions to the rule—water and bismuth. Their specific volume being greater in the solid than in the liquid state, pressure lowers, instead of raising their point of fusion. That of ice lowers 0°·0075 for each additional atmosphere of pressure. Mousson was able to melt ice completely, without the addition of any external heat, by a pressure of 13,000 atmospheres. Mons. Spring considers that the binding together of solid bodies under pressure is a much [illegible] general phenomenon, comparable to the liquefaction of gases. He has subjected 83 substances, of which 8 were metals, 6 metalloids, 10 oxydes and sulphides, 32 salts, and 19 carbonaceous bodies, with 8 mechanical mixtures, to compression, either under ordinary or elevated temperatures, with the following among other results. Lead in a vacuum, under pressure equal to that of 2000 atmospheres, becomes as solid as when melted; under 5000 it flows like a liquid. Bismuth welds easily under a pressure of 6000 atmospheres, breaking afterwards with a crystalline fracture. Pewter behaves like lead. Zinc requires 5000 atm. Aluminium and copper unite at 6000 atm. Antimony in grey powder recovers solidity and metallic lustre at 5000. Platina welds imperfectly with pressure alone. Of the three allotropic forms of sulphur, the transparent prismatic form at 5000 atm. became harder than that obtained by fusion, and probably octahedral, a form which the plastic variety also took at 6000 atm. The octahedral form itself welds easily at 3000 atm. Amorphous carbon refuses to solidify under any pressure whatever, and exhibits the most perfect elasticity. Graphite, on the contrary, as is well known, agglomerates to a solidity equal to the native material. Peroxyde of manganese took the exact appearance of crystalline pyrolusite. Alumina became translucent, like the mineral known as Halloysite, flowing like a liquid, but showing no tendency to assume the form of corundum. Sulphide of lead became galena. Many chlorides, bromides, and iodides welded and became transparent. Mercuric iodide took a violet colour. Nitrate of potash became plastic like wax at 3000 atm., as did hyposulphite of sodium. Glass resisted at every pressure. Turf became practically coal, losing all trace of organic structure, and coking in a close vessel just like coal, a result of some geological importance.

Pressure was also found to influence chemical combination. For instance, under a pressure of 5000 atms. sulphur and metallic copper combine perfectly. Mercuric chloride and the same metal change places, metallic mercury and cuprous chloride, free from cupric chloride, being left.

M. Spring points out (1) that under compression, the attraction of particles follows the direction of the crystalline axes; (2) that crystalloids coalesce better than amorphous bodies; (3) that after welding, many bodies reputed solid flow like liquids. The compressing apparatus is described as consisting either of screws or powerful levers weighted at their end. Hydraulic compression is not alluded to.

Musical pitch and its determination formed the subject of a recent lecture at the Royal Institution by Dr. W. H. Stone. He pointed out that absolute pitch does not exist in nature, the exceptional power of recognizing a note, or hearing it, being really an acquirement connected with the 'muscular sense' in singers, and musical memory highly developed in organists and instrumentalists generally. After defining pitch as rapidity of vibration, he considered (1) the causes and amount of variation in different sound-producers; (2) scientific methods of measuring pitch; (3) the musical application of such methods.

1. Heat variations were illustrated by metallic strings, organ-pipes, harmonium-reeds, and tuning-forks.

2. The mechanical, optical, photographic, electrical, and computative methods of determining pitch, were exhibited and explained. These included

an exact copy of Colonel Perronet Thompson's *Monochord*, bearing a weight of 240 lbs. to produce Tenor C, and Professor McLeod's ingenious modification of Lissajous's figures in the cycloscope. He laid much stress on the computative method, on account of its extreme simplicity and accuracy. By it absolute was first obtained from relative pitch. Scheibler's *Tonmesser* and Appunn's reed-tonometer were exhibited, as well as a photograph of Kœnig's tuning-fork clock.

3. The problem of absolute pitch having now been satisfactorily determined, its application only needed time and patience, the present state of the matter being discreditable to England. Since Handel's time, pitch had risen about a semitone. This was attributed to (1) the excess of true fifths, as tuned to by violins, over the corresponding octaves; (2) the rise with heat of the wind instruments; (3) the difficulty of appreciating slow beats; (4) the predominant effect on the ear of a sharp over a flatter note. The voice—God's instrument—should be consulted in preference to man's less perfect instruments. The difference, however, between the present high orchestral pitch and the French normal diapason which, as a standard, had been proved to be both accurate and convenient, is less great melodically than is often supposed. Indeed the ear, unassisted by beats, was all but unable to detect the difference. The main need of modern music was a greater familiarity with the physical principles upon which it rests.

ZOOLOGY.

Abyssal Crustacea of the West Indies.—Prof. A. Milne-Edwards has laid before the French Academy of Sciences a general statement of the results of his investigation of the Decapod Crustacea dredged up from great depths in the West Indian seas, by the U. S. exploring ship *Blake* (*Comptes Rendus*, 21 February, 1881).

The family Galatheidæ has always been regarded as wanting in American waters; among these collections there are forty-one species, mostly constituting new genera, although thirteen of them belong to the widely distributed genera *Galathea* (2) and *Munida* (11). True Crabs do not occur at very great depths; numerous small species are found down to about 250 fathoms, and at about 400 fathoms a new form allied to the well-known European genus, *Gonoplax*, was obtained. This animal, described by Prof. Milne-Edwards under the name of *Bathyplax*, is blind, its eyes being atrophied and destitute of facets, and its orbits rudimentary. The Anomurous and Macrurous Decapods, on the contrary, swarm at great depths. Down to about 1800 fathoms the curious genus *Willemoesia* was represented; its species are apparently most nearly related to the well-known Eryons of the Jurassic rocks, but the deep-sea forms examined by M. Milne-Edwards were blind. The Galatheidæ already mentioned occurred at still greater depths, down to more than 2000 fathoms, from which depth came species of a new genus (*Galathodes*) having the eyes greatly reduced and imperfectly facetted. The most interesting types are those belonging to the family Paguridæ, represented hitherto by the well-known Hermit Crabs, which, although numerous in species, are all very similar and show no indications of an alliance with the Macrura, such as the Shrimps and Lobsters. Among the West Indian dredgings, however, such intermediate forms seem to abound. Thus *Pylocheles Agassizii* is described as connecting the Hermit Crabs with the Thalassinidæ; the abdomen, instead of being soft and unsymmetrical as in the former, is composed of firm, regular rings, and terminated by a symmetrical fin. This animal lives in holes, the entrance to which it closes with its claws. In *Mixtopagurus*, the abdomen is more developed on the right than on the left side, and divided into seven joints, of which the first five are imperfectly calcified, and the last two large and hard. In *Ostraconotus* the carapace is coriaceous, and the abdomen so small that the female uses the legs of the fourth pair to hold her eggs; the last joint but one in these limbs is widened into a palette forming a floor on which the eggs rest. *Spiropagurus* and *Catapagurus* have a very small, twisted abdomen which the animals lodge in small spiral shells, contrasting curiously with the much larger carapace and legs which remain exposed. *Eupagurus discoidalis* inhabits the tubular shells of *Dentalium*, the orifice of which it closes with its claws. *Xylopagurus* inhabits holes in fragments of wood and the cavities of reeds, rushes, &c.; the cavities are open at both ends, and the Crustacean does not go into its dwelling tail foremost after the fashion of the Hermit Crabs, but crawls in and closes one aperture with its claws and the other with the end of the abdomen which is converted into an opercular shield. Among the Dromiidæ there are numerous forms leading towards *Homola* and its allies, and the genus *Homola* itself is represented by two species, one of which appears to be identical with the Mediterranean *H. spinifrons*, thus furnishing a striking example of the wide distribution of animals inhabiting the great depths of the sea. The genus *Cymopolia*, of which one species inhabits the Mediterranean, possesses eight in the Caribbean Sea. The genus *Ethusa*, supposed to be peculiar to the Mediterranean, is also found in the American seas; M. Milne-Edwards has described a species from the Florida reefs under the name of *E. americana*, but states that it differs from the Mediterranean *E. mascarone* only by characters of little importance.

It is impossible to overrate the value of such results as the above, and M. Milne-Edwards is quite justified in commenting with some pride upon the important bearing which such investigations must have upon our conceptions of the system of Nature. As one instance of this, he indicates that the results of the *Travailleur's* expedition of last year in the Bay of Biscay showed the existence, in close proximity on the Spanish coast and in the neighbouring deep water, of two distinct faunas belonging neither to the same time (geologically speaking) nor to the same climate; and he specially calls the attention of geologists to this fact as showing that at the present day and in the same seas, there must be in course of formation deposits absolutely contemporaneous, but which will contain the remains of perfectly dissimilar animals. The littoral deposits will contain the types of higher organizations; the deposits formed at great depths will contain creatures of a more ancient character, some of them presenting unmistakable affinities with fossils of the secondary epoch, while others resemble the larval forms of existing species.

We are glad to learn that the success of last year's expedition will induce the French Government to send out the *Travailleur* again this summer on a dredging expedition; this year the scene of her labours will be the Mediterranean.

The Crustaceans referred to above are described by Prof. Milne-Edwards in the Bulletin of the Museum of Comparative Zoology in Harvard College, Vol. viii., No. 1.

Terrestrial progression of Callichthys.—According to Mr. Joseph Mawson of Bahia (*Science*, December 25, 1880), the Brazilian Siluroid fish, *Callichthys asper*, is very active on dry land. Mr. Mawson says:—'During the rainy season the fish live in fresh-water pools. When the pools dry up in the dry season, they bury themselves in the mud, and remain there until the rains return the following year. They are noted for overland excursions. It is said that they are often met with going from one pool to another. I have had six of the fish in a narrow-necked tin of water, with some sand and mandioca meal at the bottom, for five days, and they continue active and vigorous, especially the smaller ones. These examples measure from 5 to 10 cm. in length, and I have seen them much larger. I have had them out in the garden several times. I find that they move best on smooth damp ground, and are embarrassed by sticks or other inequalities. They can jump a little vertically, but their progress on land is effected entirely by a quick wriggling motion of the body, which is nearly flat upon the ground. The paired fins (pectorals and ventrals) are extended laterally, and seem to bear little if any weight; but they move slightly, and appear to serve to steady the body. Last night I heard a peculiar sound, and on looking around, I saw one of the fish travelling about the room. He had escaped from the tin which was in my bed-room, had fallen from the table to the floor, and travelled along the corridor, about 12 metres (about 40 feet), to the *sala*. I watched him travelling for two hours, during which time I estimate that he moved at least 90 metres. Toward the end of the two hours he seemed to flag a little, but in the earlier part his method and speed were fairly seen. He seemed to start with a sudden movement of the head or the barbels, then wriggled briskly for 5 to 10 seconds, advancing about a metre. Then he would rest for about 10 seconds, and start as before. This was kept up during the whole two hours, and I left him still moving. This morning, five hours later, I found him dead. While he was moving I spilled some water on the floor, but he crossed it; hence I concluded that it was mud rather than water of which he was in search.'

Trichinosis.—The spread of *Trichinosis* in American pigs is producing very serious consequences, not only in North America, but also in Europe, owing to the great importation of pork, hams, &c., from the United States. In France considerable alarm prevails, and the most opposite opinions seem to be held—some writers maintaining that ordinary salting is sufficient to destroy the *Trichinæ*, whilst others declare that salting, smoking, and even ordinary cooking, will not give the requisite safeguard. M. J. Chatin (*Comptes Rendus*, 28th February, 1881), declares that the examination of the encysted *Trichinæ* in salted provisions seems to show that these parasites are in a state of absolute functional integrity, for he says, 'We know that their passage from latent life to death is regularly manifested by important modifications in the nature of the cyst; fatty matter accumulates rapidly, then calcareous granules appear and multiply quickly, effacing all traces of the original constitution.' None of these phenomena were presented by the *Trichinæ* observed by him. The ordinary course of experiment to decide whether the *Trichinæ* are really alive consists in heating the trichinized meat to 40° or 45° C. (104° or 113° F.), and then examining whether the encysted larvæ show any signs of movement. If not, the meat is regarded as innocuous; but M. Chatin holds that this conclusion must be accepted with reserve, seeing that the action of heat only reproduces one of the conditions necessary for the ulterior development of the parasites. His own test consisted in the administration of small quantities of trichinized salt pork to two guinea-pigs. On the fourth day diarrhœa set in, and rapidly increased; on the eighth day one of the animals died, and the other on the fifteenth day. Examination showed all the signs of acute enteritis; and further, the intestine contained numerous adult, sexually mature *Trichinæ*. The females showed normally developed embryos, which were also met with free in the contents of the intestine. In the guinea-pig that survived till the fifteenth day, young *Trichinæ* had already got into the muscles, but had not yet become encysted.

M. Bouley (*Comptes Rendus*, 7th March, 1881) seems to think that there is little danger of the spread of trichinosis in France, and accounts for this supposed immunity by the fact that such provisions as might communicate the parasite are thoroughly cooked in that country, the *Trichinæ* not being able to survive exposure to a temperature of 70° C. (158° F.). In spite of such encouraging statements, the French public appear to prefer having their pork untrichinized, and M. Bouley himself has been appointed by the Government to organize a system of inspection at Havre.

A Gigantic Japanese Cuttlefish.—M. Hilgendorf describes (*Sitzungsber. Gesellsch. Naturf. Freunde zu Berlin*, 1880) a gigantic Cuttlefish, which was captured in the Japanese sea in 1873, and exhibited in Yedo for money as a curiosity. It did not attain the size of the specimens obtained some years ago off the coast of Newfoundland, some of which were estimated to exceed 50 feet in total length, including the long tentacular arms, while indisputable measurements of one specimen give the length of the body as $9\frac{1}{2}$ feet, and that of the long arms at 30 feet, making nearly 40 feet in all.[*] The Japanese Cuttlefish was, however, a sufficiently formidable animal; the length of its body (the head estimated) was about $7\frac{1}{2}$ feet, and that of the longest arm preserved, $6\frac{1}{2}$ feet. The long tentacles had been cut off, but M. Hilgendorf estimates that when they were perfect, the total length of the animal must have been at least 20 feet. He was at first inclined to refer this Cuttlefish to the genus *Ommastrephes*, but, on further consideration, makes it the type of a new genus, and names it *Megateuthis Martensii*. The generic name is already preoccupied by Mr. Savill Kent's *Megaloteuthis*, proposed for one of the Newfoundland specimens, and it is a question whether the characters indicated by M. Hilgendorf are sufficient to separate the Japanese species generically from *Architeuthis*, Steenstr. Nevertheless the record of the occurrence of a gigantic squid in the Japanese seas is of interest.

The Organs of Taste in Fishes.—M. E. Jourdan has presented some remarks upon this subject to the French Academy (*Comptes Rendus*, 21st March, 1881).—Schulze nearly twenty years ago described certain cyathiform bodies in the Barbel and in the tadpoles of *Pelobates fuscus*, which he found to agree in structure with similar bodies in the tongues of Mammalia, and was led to believe that the two sets of bodies possess the same functions. M. Jourdan has investigated several fishes, and especially the Malarmat (*Peristedion cataphractum*) at the Marine Zoological Laboratory of Marseilles, and his observations confirm Schulze's conclusions. The Malarmat (a member of the Gurnard family) possesses barbels like those of the Red Mullet (*Mullus barbatus*), and free fine rays identical with those of the Gurnards. The barbels, which may be either tufted or isolated, are attached, to the number of ten or twelve, to the lower jaw; two of them are always large, and present secondary ramifications. They are always furnished with small cyathiform bodies containing two kinds of cells; some, grouped in the centre, and slightly projecting at the surface of the barbel, resemble fibres with a voluminous nucleus; the others, arranged at the periphery, are cylindrical. These organs exist also in considerable number in the mucous membrane lining the cavity of the mouth: they are arranged serially in the pharynx, and the papillæ of the rudimentary tongue have three or four of them. They are always in the epidermis.

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[*] *See some observations of* Prof. Verrill's, p. 190.

In the Mullet the cyathiform bodies are much larger. They are like those described by Schulze in the Barbel and Tench. Each corpuscle is placed at a point in the epidermis corresponding to a papilla of the dermis; it is clearly distinguished from the cells which surround it by the dark colour it acquires by the action of osmic acid, and the aspect of the elements forming it. Each is formed of cells of two types, between which all transitional forms are observed; namely, cylindrical, peripheral cells, and cells grouped in the centre of the ovoid body, which terminate in conical processes, the points of which are not so distinct in the Malarmat. All possess a voluminous nucleus. At the base of each corpuscle is a small granular mass formed by the varicose basal prolongations of the cells of the body; in the granular mass the cylinder-axes of the nervous fibres disappear, and the cells of the corpuscles originate. Identical bodies occur in the mucous membrane of the tongue and pharynx.

The Gurnards have cyathiform corpuscles on the tongue; and they probably exist in the buccal mucous membrane of most fishes.

If these cyathiform bodies are to be regarded as taste-organs, whether external or internal, the sense of taste appears to acquire an importance in fishes which may be justified by the nature of the medium in which the animals live. 'The search for food,' says the author, 'must be guided by sensitive terminations more particularly destined to the reception of gustative emanations; this explains the distribution of the cyathiform corpuscles upon external organs, exploratory apparatus, the situation of which has deceived observers, but which need no more surprise us than the existence of well-formed otoliths, far from the head, upon the last segments of *Mysis*.'

Giant Squids on the Newfoundland Banks.—Professor Verrill has published (*Amer. Journ. Sci.*, March, 1881) an account of the occurrence of Giant Squids of the genus *Architeuthis* in great abundance upon the Grand Banks in the year 1875. He states that he has been informed by Capt. J. W. Collins that in October of that year a great number of these animals were found floating at the surface over the Grand Banks, mostly quite dead, and more or less mutilated by birds and fishes. In a few cases they were not dead, but completely disabled. They were seen chiefly between 44° and 44° 30′ N. lat., and between 49° 30′ and 49° 50′ W. Long. From twenty-five to thirty specimens were said to have been secured by the fleet from Gloucester, Mass., and as many more were probably obtained by the vessels from other places. They were cut up as bait for codfish. Capt. Collins himself was in command of the schooner *Howard*, which secured five squids to her own share. They were mostly from ten to fifteen feet long, exclusive of the arms, and averaged eighteen inches in diameter. The arms were generally mutilated, the portions left being usually three or four feet long, and, at the base, almost as thick as a man's thigh. One specimen, when cut up, was packed into a large hogshead-cask holding about 75 gallons, which it filled. This cask would hold 700 pounds of codfish, and as the specific gravity of the *Architeuthis* is almost equal to that of codfish, we may take this as an approximate indication of the weight of one of these gigantic Cephalopods. Allowing for the lost parts of the arms, this specimen would probably, when entire, have weighed about 1000 pounds; previous estimates are too high.

Professor Verrill refers to other vessels which secured portions of the valuable supply of bait furnished by these great squids, and states that the *E. R. Nickerson*, Capt. McDonald, obtained one which had its arms, and was not quite dead, so that it was harpooned. Its tentacular arms were thirty feet long. The schooner *Tragabigzanda* secured three in one afternoon; they were from eight to twelve feet long, not including the arms. Other fishermen confirm these statements, and some of them add that the 'big squids' were common during the same season at the 'Flemish Cap,' a bank some distance north-west of the Grand Banks.

With regard to the cause of this remarkable mortality among these great Cephalopods, Professor Verrill suggests that it may have been due to some disease epidemic among them, or to an unusual prevalence of deadly parasites or other enemies. He indicates, however, as a point worthy of notice, that they were observed at the same season of the year when most of the specimens have been found on the shores of Newfoundland. This season may, perhaps, be immediately subsequent to the period of reproduction, when the animals would probably be so much weakened as to succumb easily to parasites, disease, or any other unfavourable conditions.

Disappearance of the muscles of larvæ in the pupæ of Dipterous Insects.—It is well known that many of the internal organs of the larvæ of insects melt away, as it were, when the insect passes into the pupa state, so that the pupa may not unaptly be likened to a second egg in which new organs are produced from a formative fluid. M. Viallanes has communicated to the French Academy (*Comptes Rendus*, February 21) an interesting description of his observations on the disappearance of the larval muscles in the pupæ of Diptera, founded upon the examination of more than 400 transverse sections of larvæ and pupæ. The primitive bundles enclosed in their sarcolemma exhibit nuclei, some of which are situated just within the sarcolemma, while others are in the midst of the contractile substances of the muscle. From the first day of pupal life the primitive bundles begin to disappear, and this disappearance takes place in two modes,—

1. By the excessive activity and proliferation of the nuclei;
2. By their degeneration and death.

In the first mode the sarcolemma speedily vanishes, the contractile substance becomes homogeneous, and the nuclei become spherical, and soon acquire the value of complete cells. They are surrounded by a layer of protoplasm, enveloped by a membrane. In this protoplasm four or five spherical granules make their appearance, and soon attain the size of the nucleus, producing a mulberry-like mass of five or six grains enclosed in a common envelope. The enveloping membrane disappears and the grains separate, and again multiply by a process analogous to that already described. As these embryonic cells increase in number the contractile substance is absorbed, and at a more advanced stage the place originally occupied by the muscular bundle shows only a mass of embryonic cells engaged in constant proliferation.

In the second mode the sarcolemma also disappears, and the muscular nuclei show a very distinct envelope presenting a double contour. They still retain their original lenticular form, and their centre is occupied by a small spherule composed of fine granules. These granules become fewer and fewer; they separate and finally disappear, when the nucleus is represented only by its empty envelope. While these changes are going on the contractile substance gradually disappears, by a sort of melting away, but without altering the general form of the bundle, finally producing a colourless, very finely granular substance, containing the original nuclei in any stage of the degeneration just described.

Habits of Callichthys faciatus.—M. Carbonnier records some curious particulars of the habits of *Callichthys faciatus*—a Siluroid fish from the rivers of South America. His observations are made upon specimens from the Rio de la Plata, living in his aquarium, and relate chiefly to the reproduction of the fish. He states that when about to deposit her eggs the female brings together the ventral fins in such a manner as to form a sort of pouch, in which the fertilizing elements furnished by the male fish are received and retained. The ovarian orifice is at the bottom of this sac, and through it some five or six eggs are extruded into the sac, where they are of course surrounded by a fluid charged with spermatozoids. To secure impregnation the female retains the eggs in the pouch formed by the ventral fins for a short time before finally depositing them. For the latter purpose she selects a spot, usually well illuminated, which she cleans with her mouth from all adhering vegetation, or other inconvenient objects, and then applying her abdomen to the place, opens the sac and attaches the eggs, which adhere by means of the viscosity with which they are endued. The same process is repeated until all the eggs—numbering about 250 for each female—have been laid. The young fish are developed and able to swim about in from twelve to thirteen days; but their further development is comparatively slow, as they do not appear to become adults until two years after hatching. A singular fact mentioned by M. Carbonnier is the change that has taken place with his *Callichthyes* in the season of oviposition since their transportation to Europe. In the Rio de la Plata the eggs are laid in October and November. After being in Europe for a year the South American specimens bred in August and September, 1878, and the young fish thus produced have their eggs in the month of June. This would seem to indicate an adaptation to the change of climate to which the fish have been subjected, the seasons in South America being the reverse of those in Europe (*Comptes Rendus*, 6 December, 1880).

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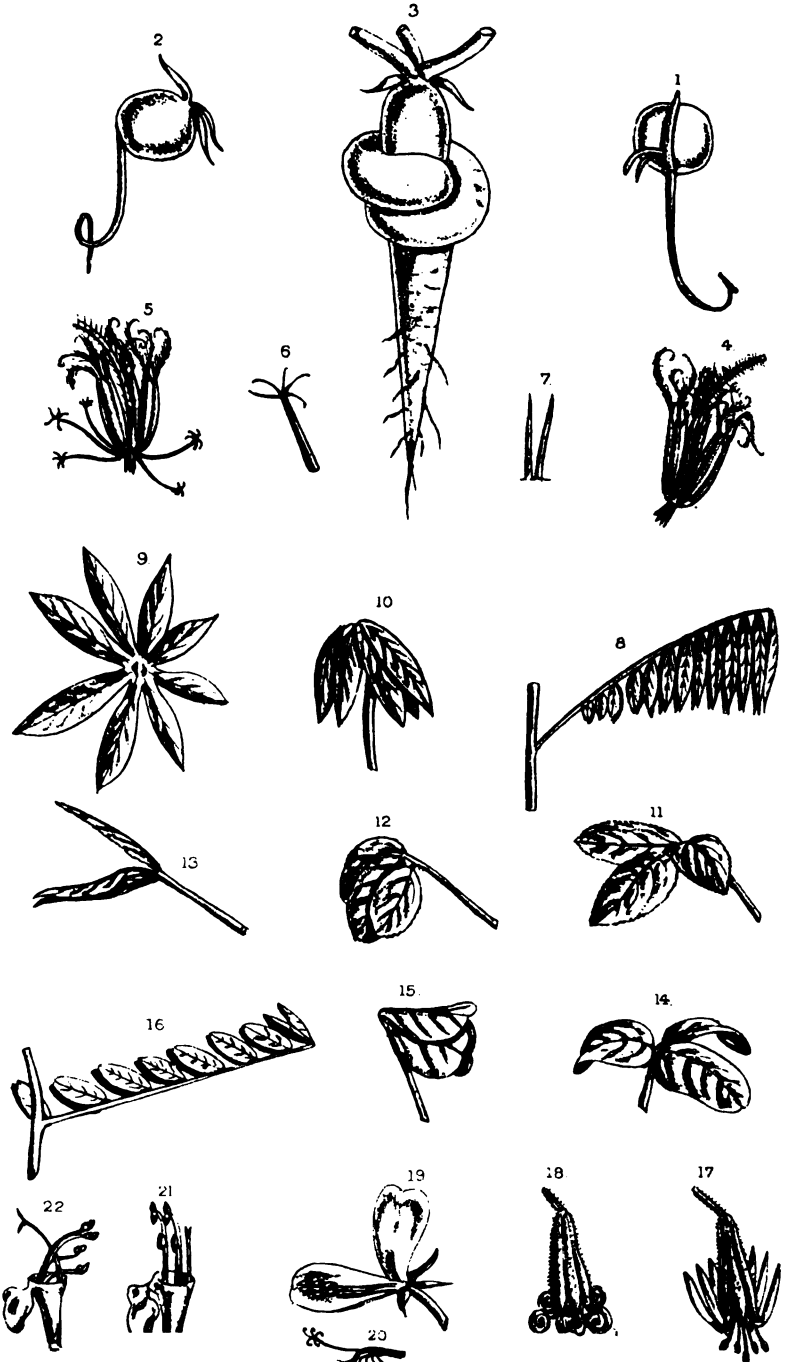

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ONS OF PLANT MOVEMENTS.

THE MOVEMENTS OF PLANTS.

By the Rev. GEORGE HENSLOW, M.A., F.L.S., F.G.S.

[Plate V.]

THE old distinction between plants and animals, that the latter can move and the former cannot, has long since been abandoned as unscientific, and only lingers as a copy-book assertion; but that all plants, even when permanently fixed to the soil, have their stems, leaves, flower-stalks, &c., in almost perpetual motion, is a discovery of quite recent times, and notably due to the investigations of Mr. Darwin. His latest work, which bears the title of this article,* is a treatise based on the most careful and elaborate experiments on the motions effected by the different organs of plants; and it was thought that a brief exposition of the chief of these, as well as of some movements peculiar to the parts of flowers not alluded to by Mr. Darwin, might be interesting to the readers of the *Popular Science Review.*

The majority of the movements can be embraced under the single term *circumnutation* and its modifications; it signifies a 'bowing around.' The stem, leaf, or other organ, when circumnutating, bends to all points of the compass successively, with a sort of rolling motion, so that the side which is uppermost in any direction becomes lowermost when it points in the opposite one. The circles or ellipses thus described by the apex of the organ, are most perfectly seen in the circumnutation of the stems of climbing plants; other organs for the most part move in ellipses, but with frequent interpolations of zig-zags, triangular loops, &c. The *projections* of such motions, when observed for some hours, exhibit most complicated and intricate lines; a great number of these projections are given by Mr. Darwin. With regard to the cause of circumnutation, Mr. Darwin says that on the whole we may at present conclude that increased growth, first on one side and then on another, is a secondary effect; and that the increased turgescence of the cells, together with the extensibility of their walls, is the primary cause of the movement of circumnutation.*

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* *The Power of Movement in Plants.* By Charles Darwin, LL.D., F.R.S., assisted by Francis Darwin. 8vo. London: Murray. 1880.

It will be advisable to treat of the different organs in a definite order, so I will proceed to describe the motions of radicles, cotyledons, hypocotyls, and epicotyls of germinating seeds; then will follow those of the stems and leaves of fully developed plants; and finally, the movements effected by the different organs of the floral region.

RADICLES.—The tip of the radicle, as soon as it protrudes from the seed-coat, begins to circumnutate, and the whole growing part continues to do so, probably for as long as growth is maintained; it presumably is aided by this motion in being guided along lines of least resistance. As soon as the radicle has protruded, *geotropism* at once acts upon it. If this force be identical with gravitation, it is gravitation acting in a peculiar way; for although the radicles of germinating seeds, whether in England or at the Antipodes, point to the centre of the earth, yet the influence affects the tip only, for a length of no more than the ·02 to ·03 of an inch, at least, in the cabbage. This minute part, however, at once communicates some influence to a point further back, where the radicle bends downwards in response to it; neither geotropism nor circumnutation can enable the radicle to penetrate the soil. This is effected by the force due to growth both longitudinally and transversely. By means of ingenious contrivances, seeds were grown under resistance; and Mr. Darwin found that transverse growth exerted a force, after six days, of more than 8 lbs., and vertical growth, after twenty-four hours, of at least a ¼ lb. The *purchase* for the due effect of these forces is gained partly by the seed being below the soil, aided by the root-hairs, which, in consequence of the cellulose passing into a gum-like substance, fix the radicle to the particles of the soil. The growing part, therefore, acts like a wedge of wood, which whilst slowly driven into a crevice, continually expands at the same time by the absorption of water; and a wedge thus acting, Mr. Darwin observes, will split even a mass of rock.

Another important property of radicles is their extreme sensitiveness to irritants, such as mechanical obstructions, caustic, and injuries by being cut, all of which induce the radicle to *bend away* from the exciting cause, as well as to the presence of moisture, which, on the contrary, induces the radicle to *bend towards* it. Any solid body which gives rise to a permanent obstruction to a radicle, causes the latter to deviate from its path till it finds no great resistance; and Mr. Darwin observes that this is the only-known instance of an organ turning *away* from an irritant. By fixing cards to one side of the tips of vertically growing radicles, they were caused to tend upwards, as if trying to escape from the cards, sometimes even forming complete circles, and in one case a radicle actually tied itself into a knot (Pl. V. fig. 3*). The tip in the act of forming a loop, generally rubs against the upper part of the radicle and pushes off the attached card; the loop then contracts or closes, but never disappears. The apex afterwards grows vertically downwards (fig. 2). This sensitiveness is confined to the tip for a length of from 1 mm. to 1·5 mm., while the upper adjoining part of the radicle, for a length of from 6 or 7 to even 12 mm., is excited to bend away from the side which has been irritated. After a time the radicle apparently becomes accustomed to the irritation, as occurs in the case of tendrils, and the irritant no longer affects its downward growth, which is resumed.

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* P. 2, 3. I have not here or elsewhere added inverted commas, for throughout this paper I have largely interwoven Mr. Darwin's sentences with my own.

After a radicle, which has been deflected by some stone or root from its natural downward course, reaches the edge of the obstacle, geotropism will direct it to grow again straight downwards; but geotropism is a weak force, and the radicle assists it by having its upper part, a little above the apex, sensitive to contact, but acting in a directly opposite manner to that of the tip, for it causes the radicle to bend like a tendril *towards* the touching object, so that as it rubs over the edge of an obstacle it will bend downwards. This downward bending coincides with that due to geotropism, and both will cause the root to resume its original course.

Finally, Mr. Darwin observes,† the several co-ordinated movements by which radicles are enabled to perform their proper functions are admirably perfect. In whatever direction the primary radicle first protrudes from the seed, geotropism guides it perpendicularly downwards; the radicles emitted from the primary are, however, only acted upon by geotropism in such a manner as to cause them to bend obliquely downwards, unless the end of the primary radicle be cut away, then the secondary ones grow vertically downwards. The tertiary radicles are not influenced by geotropism; hence all the rootlets grow in the most advantageous manner, and the whole soil is thus closely searched.

HYPOCOTYLS and EPICOTYLS.—The radicle having penetrated the soil, the hypocotyl, as the axis below the cotyledons is called, begins to develope, at least in those seeds which elevate their cotyledons above ground; but it is the plumule or epicotyl which alone does so of seeds which retain their cotyledons below the soil. In either case the organ commences its growth in the form of an arch, such being the result of an innate tendency in the case of the plumule to assume that form; the inner concave surface then growing more rapidly than the outer and convex, tends to raise the summit of the arch out of the ground. The apex of the stem, being ultimately freed from the soil, soon straightens itself and becomes erect.

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* The figure of the radish is not from Mr. Darwin's work, but from a drawing made many years ago, and which would seem now to have received its explanation.

† P. 196.

In whatever position the seeds may lie, *apogeotropism* acts upon the arch, and the two legs become vertical; the entire arch circumnutates more or less the whole time as the nature of the soil permits. Mr. Darwin aptly compares the whole process of extrication of the arch from beneath the soil to a man thrown down on his hands and knees, at the same time to one side, by a load of hay falling upon him. He would first endeavour to get his arched back upright, wriggling at the same time in all directions to free himself a little from the surrounding pressure; and this may represent the combined effects of apogeotropism and circumnutation. The man, still wriggling, would then raise his arched back as high as he could; as soon as the man felt himself at all free, he would raise the upper part of his body, whilst still on his knees and still wriggling. This will represent the bowing backwards of the basal leg of the arch, which aids in the withdrawal of the cotyledons from the buried and ruptured seed-coats.

COTYLEDONS.—Colytedons are in constant movement, chiefly in a vertical plane, and commonly rise up once and descend once in 24 hours; some move much oftener, thus, those of *Ipomœa cœrulea* moved thirteen times either upwards or downwards in 16^h 18^m. As the motion when perfected gave ellipses, cotyledons may be said to circumnutate. In a large majority of instances observed by Mr. Darwin, the cotyledons sank a little downwards in the forenoon, and rose a little in the afternoon or evening, thus exhibiting a certain periodicity in their movements, no doubt in connexion with the daily alternations of light and darkness. When the cotyledons rise or fall to such a degree as to be vertical, or at an angle of at least 60° above or below the horizon, they are said to be asleep; the object gained being, as in leaves, to escape injury by radiation at night.

STEMS.—Several experiments with stems of plants of various orders, showed that they continually circumnutate; and in the *case* [illegible]m-climbers the circumnutation is of the most perfect kind.* An interesting modification of the process occurs in stolons or runners, which consist of much elongated flexible branches, that run along the surface of the ground and form roots at a distance from the parent plant; the circumnutation is so great in amplitude, that it may almost be compared with that of climbing plants. The stolons are thus aided in passing over obstacles, and in winding between the stems of surrounding plants.

PEDUNCLES.—Flower stems form no exception to axial structures in the habit of circumnutating; but the effect is curiously modified by geotropism in the case of *Trifolium subterraneum*, and by apheliotropism in that of *Cyclamen Persicum*, in both of which plants the object gained is the burying the unripe pods beneath the soil, leaves, &c. The flower-heads of *Trifolium subterraneum* produce but three or four perfect flowers at the base, all the other flowers above consisting only of cylindrical calyx-tubes with stiff spreading lobes, forming claw-like proections (Pl. V. figs. 4–6). As soon as the perfect flowers wither, they bend back upon the peduncles. This movement s due to *epinasty*, a word coined to imply that the upper surface f an organ grows more quickly than the lower surface, and hus causes it to bend downwards. Whilst the perfect flowers are thus bending, the whole peduncle curves downwards and ncreases much in length, even from 6 to 9 inches if necessary, until the flower-head reaches the ground. At this period the younger, imperfect, central flowers are still pressed closely ogether, and form a rather rigid conical projection. The depth to which the flower-heads can penetrate varies from 25 to ·06 inch. In the case of a plant kept in the house, a head partly buried itself in sand in 6 hours; with plants growng out-of-doors, Mr. Darwin believes that they bury themselves n a much shorter time. After the heads are buried, the central aborted flowers increase considerably in length and rigidity, and become bleached; they gradually curve, one after the other, upwards or towards the peduncle (fig. 5). In thus moving, the long claws on their summits carry with them some earth; hence a flower-head which has been buried for a sufficient time forms a rather large ball, the aborted flowers having caught up the earth with the claw-like sepal-lobes, act somewhat like the hands of a mole, which force the earth backwards and the body forwards.

The calyxes of all the flowers are clothed with simple and multicellular hairs (fig. 7), which, on absorbing carbonate of ammonia presented to them, exhibited protoplasmic aggregation. As Mr. Darwin observes that only a few of the flower-heads, which from their position are not able to reach the ground and bury themselves, yield seeds, whereas the buried ones never failed to produce as many seeds as there had been perfect flowers, it may be reasonably conjectured that the object gained is to nourish the ripening seeds directly through their surfaces, and so to supplement root action. The capsules of Cyclamen and of the Wood Sorrel, *Oxalis acetosella*, are occasionally buried, but then only beneath dead leaves or moss.

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* For full description of twiners and other climbing plants, the reader is referred to Mr. Darwin's work on *The Movements and Habits of Climbing Plants*. See also *Pop. Sci. Rev.* vol. v. p. 55.

Leaves.—The movements of certain leaves which are said to sleep, have long been observed, but it would seem that probably all leaves and cotyledons circumnutate, and that the so-called sleep is only a remarkable modification or development of this general kind of movement, accompanied, however, by other and often complicated motions. The seat of the movement generally lies in the petiole, but sometimes both in the petiole and blade, or in the blade alone. The movement is chiefly in a vertical plane; but as the ascending and descending lines never coincide, there is always some lateral movement, and thus irregular ellipses are formed. There is a periodicity in the movements of leaves, for they often or generally rise a little in the evening and early part of the night, and sink again on the following morning, this periodicity being determined by daily alternations of light and darkness, as already mentioned in the case of cotyledons. These periodic movements occur where there is no *pulvinus*, for where this is found, the movement is amplified into *nyctitropic*, or sleep-movements.

Leaves, Mr. Darwin says, when they go to sleep, move either upwards or downwards; or in the case of the leaflets of compound leaves, forwards, that is, towards the apex of the leaf, or backwards, that is, towards its base; or again, they may rotate on their own axis without moving either upwards or downwards; but in almost every case the plane of the blade is so placed as to stand nearly or quite vertically at night. Moreover, the upper surface of each leaf, and more especially of each leaflet, is often brought into close contact with that of the opposite one, as the upper surfaces appear to require more protection than the lower.

The nyctitropic movements of leaves and cotyledons are effected in two ways, firstly, by means of pulvini, which become ultimately more turgescent on opposite sides; and secondly, by increased growth along one side of the petiole or mid-rib, and then on the opposite side. This difference between the two [illegible]ns of movement consists chiefly in the turgescence of the [illegible] of a fully-developed pulvinus not being followed by growth. The movements effected by growth on the alternate sides are confined to young growing leaves, whilst those effected by means of a pulvinus last for a long time.

The evil effects which result if sleeping leaflets be prevented from pressing their upper surfaces together, so as to protect them from radiation, were well seen in experiments of Mr. Darwin's, in which he pressed down the leaflets of *Oxalis*, *Marsilia*, &c., so that they could not bring their upper surfaces into contact; the result was that the leaves were killed. Thus of twenty-four leaves of *Marsilia* extended horizontally, exposed to the zenith and to unobstructed radiation, twenty were killed and one injured, whilst a relatively very small proportion of the leaves, which had been allowed to go to sleep with their leaflets vertically dependent, were killed or injured. Mr. Darwin noticed that the difference in the amount of dew on the pinned open leaflets and on those which had gone to sleep, was generally conspicuous, the latter being sometimes absolutely dry, whilst the leaflets which had been horizontal were coated with large beads of dew. Another fact observable was that when leaves were kept motionless, they are more liable to injury than when they were slightly waved about by the wind, and thus got a little warmed by the surrounding air.

Cotyledons, as well as leaves, may sleep; the former seem to do so more commonly than leaves. Of 153 genera observed by Mr. Darwin, one or more species of twenty-six of these genera placed their cotyledons at night so as to stand vertically, having generally moved through an angle of at least 60°. In a large majority of genera the movement is a rising one. In all the species of *Oxalis* observed by Mr. Darwin, the cotyledons are provided with a pulvinus; and he adds that this organ has become more or less rudimentary in *O. corniculata*, in which the amount of upward movement of the cotyledons at night is very variable, but never enough to be called sleep. Similarly, in the Leguminosæ, all the cotyledons which sleep have pulvini. As this organ has been referred to several times, it will be as well to describe it. It constitutes a cushion or joint, and consists of a mass of small cells, usually of a pale colour in the case of that attached to cotyledons, from the absence of chlorophyll, and having a convex outline. The development of a pulvinus follows from the growth of the cells over a small defined space of the petiole being almost arrested at an early stage. As a pulvinus is formed by this arrestment of the growth of its cells, movements dependent on their action may be long continued without any increase in length of the part thus provided; and such long-continued movements seem to be one chief end gained by the development of a pulvinus.

It will be desirable now to give a few illustrations of nyctitropic movements from Mr. Darwin's observations.

Averrhoa bilimbi (Pl. V. fig. 8).—The leaflets of this plant move spontaneously in a very marked manner during the day, are sensitive to touch, and sleep at night, when the leaflets hang vertically down and motionless.

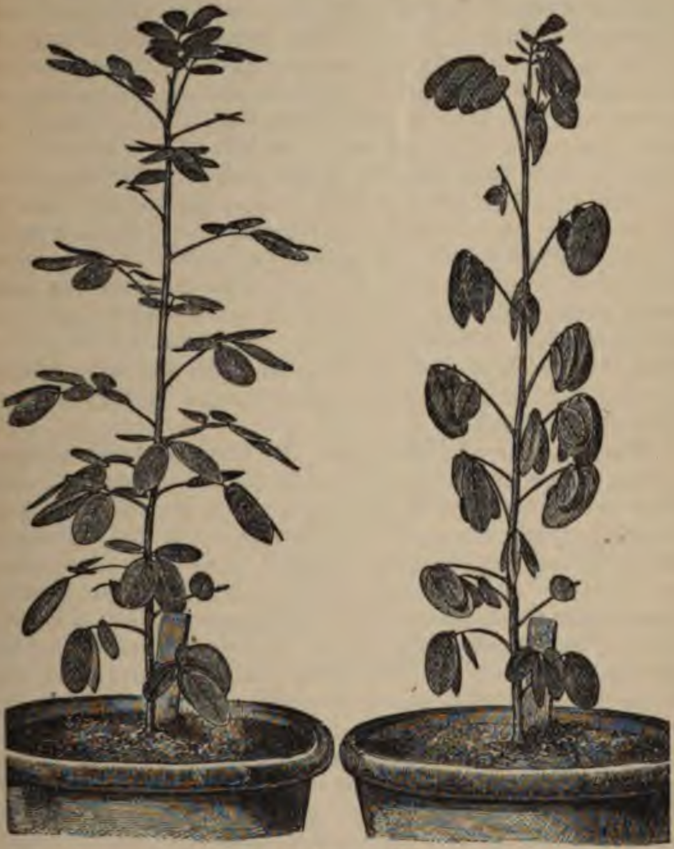
Lupinus.—The digitate leaves of this genus sleep in three different ways. One of the simplest is that all the leaflets become steeply inclined downwards at night, having been horizontal during the day, as those of *L. pilosus* (Pl. V. figs. 9, 10), when asleep are often inclined at an angle of 50° beneath the horizon. In *L. Hartwegii* and *L. luteus*, the leaflets, instead of moving downwards, rise at night, forming a hollow cone with moderately steep sides.

With several other species, the position is remarkable. On the same leaf the shorter leaflets, which generally face the centre of the plant, sink at night, whilst the longer ones on the opposite side rise, the intermediate and lateral ones merely twisting on their own axis; the result is that all the leaflets on the same leaf stand at night more or less inclined, or even quite erect, forming a vertical star.

Melilotus.—The species in this genus sleep in a curious fashion. The three leaflets of each leaf twist through an angle of 90°, so that their blades stand vertically at night, with an edge presented to the zenith; the two lateral leaflets always twist so that their upper surfaces are directed towards the terminal leaflet. This latter leaflet moves in another and more remarkable manner, for whilst its blade is twisting and becoming vertical, the whole leaflet bends to one side, and invariably to the side towards which its upper surface is directed; so that if this surface faces (say) the west, the whole leaflet bends to the west, until it comes into contact with the upper and vertical surface of the western lateral leaflet. Thus the upper surface of the terminal and of one of the two lateral leaflets is well protected. It may be added that the petioles and sub-petioles continually circumnutate during the whole twenty-four hours. (Pl. V. figs. 11, 12, 13.)

Trifolium repens.—During the day, the leaflets of this plant are expanded horizontally (Pl. V. fig. 14), but at night the two lateral leaflets twist and approach each other, until their upper surfaces come into contact; at the same time they bend downwards in a plane at right angles to that of their former position, until their mid-ribs form an angle of about 45° with the upper part of the petiole, this change of position requiring a considerable amount of torsion in the pulvinus. The [illegible] leaflet merely rises up without any twisting, and bends over until it rests on and forms a roof over the edges of the now vertical lateral leaflets (fig. 15).

Coronilla rosea.—This plant affords an instance of leaflets rising at night from having been horizontal during the day. The leaflets at the same time bend backwards towards the base of the petiole, until their mid-ribs form with it angles of from 40° to 50° in a vertical plane (Pl. V. fig. 16).



Cassia corymbosa, during the day; and the same, asleep, at night.

Cassia.—The nyctitropic movements of the leaves in many species of Cassia are highly complex. Mr. Darwin's observations were made chiefly on *C. floribunda* and *corymbosa*, and he furnishes the following description. The horizontally extended leaflets sink down vertically at night, but not simply, as in so many other genera, for each leaflet rotates on its own axis, so that its lower surface faces outwards. The upper surfaces of the opposite leaflets are thus brought into contact with one another beneath the petiole, and are well protected, as shown in the woodcut.* The rotation and other movements are effected by means of a well-developed pulvinus at the base of each leaflet, as could be plainly seen when a straight, narrow black line had been painted along it during the day. The two terminal leaflets in the daytime include rather less than a right angle, but their divergence increases greatly whilst they sink downwards and rotate, so that they stand laterally at night, as may be seen in the figure; moreover, they move somewhat backwards, so as to point towards the base of the petiole. In one instance, Mr. Darwin found that the mid-rib of a terminal leaflet formed at night an angle of 36°, with a line dropped perpendicularly from the end of the petiole. The second pair of leaflets likewise moves a little backwards, but less than the terminal pair; and the third pair moves vertically downwards, or even a little forwards. Thus all the leaflets in those species which bear only three or four pairs, tend to form a single packet, with their upper surfaces in contact and their lower surfaces turned outwards. Lastly, the main petiole rises at night, but with leaves of different ages to very different degrees; thus some rose through an angle of only 12°, and others as much as 41°.

The influence of light upon the movements of plants is various. Thus the so-called heliotropic movements are determined by the direction of the light, whilst periodic movements are affected by changes in its intensity. On the other hand, apheliotropism implies that a plant bends from the light, a rare phenomenon, at least in a well-marked degree. Parts of plants under the influence of diaheliotropism place themselves more or less transversely to the direction whence the light proceeds, and are thus fully illuminated. Lastly, some leaves rise or sink or twist so as to avoid great intensity of light. Such a phenomenon, Mr. Darwin suggests, should be called paraheliotropic. All these movements consist of modified circumnutation. Space forbids a detailed description of these effects; but one curious result of Mr. Darwin's investigation is worth recording, and that is, the transmitted effects of light. When, for example, the cotyledon of *Phalaris canariensis* is exposed to light, the upper part bends first, and afterwards the bending gradually extends to the base, and even a little below the ground. By protecting the whole upper half of the cotyledon from light, the lower part, though fully exposed to light, was prevented from becoming curved. Hence it is to be concluded that when seedlings are freely exposed to a lateral light, some influence is transmitted from the upper to the lower part, causing the latter to bend.

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* [illegible] to the courtesy of Mr. Darwin for the loan of the blocks for [illegible]

FLOWERS.—There are many instances of the various parts of flowers moving under the influence of stimuli; but the immediate causes in the different cases have not been so thoroughly investigated as by Mr. Darwin in the case of the vegetative organs, and at present, therefore, but little can be said beyond the fact that they do move. Thus, commencing with bracts, it may easily be seen how the erect bracts of the involucre of the dandelion become reflexed as soon as the fruit is ripened, thus allowing the parachute-like achenes to escape easily. Moving corollas are very numerous. A large series of plants might be mentioned of which the corollas close up, either as soon as the sun is obscured, as *Mesembryanthemum*, *Anagallis arvensis*, *Convolvulus*, &c., or else at evening, such as many Compositæ, including the Daisy and Dandelion, re-expanding on the return of light. Conversely, some night-flowering plants unfurl their petals only at night, coiling them up by day. As an illustration *Silene nutans* may be taken, concerning which Dr. Kerner tells us* that a flower lasts three days and three nights; with the approach of dusk the bifid limbs of the petals spread out with a flat surface, and fall back upon the calyx. In this position they remain through the night; curling themselves up into an incurved spire and becoming longitudinally creased at the same time, on the return of sunlight and a warm temperature. No sooner does evening return, than the wrinkles disappear, the petals become smooth, uncurl themselves, and falling back against the calyx, the corolla is again expanded (Pl. V. figs. 17, 18).

In the Pea family, or Leguminosæ, there are several instances of the corolla having a power to move when irritated. Thus in the genera *Genista* and *Indigo*, the claws of the petals act like springs kept in a state of tension; for when the corolla is touched, as by an insect in search of honey, the claws suddenly curl downwards, and the petals consequently drop vertically, while the stamens, previously concealed within the keel petals, are violently thrown upwards, showering the bee with pollen.†

The movement of stamens is perhaps more curious, and apparently intimately connected with the phenomenon of insect fertilization. As an example of slow movement, *Parnassia palustris* may be mentioned. In this flower, each stamen in succession rises up, places the anther on the stigma, and having shed its pollen, retires and falls back upon the petals. Each stamen occupies about twenty-four hours in rising up and discharging its pollen, and takes about the same time to recede, the whole period being eight days, but varying according to circumstances of temperature, moisture, &c.*

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* *Flowers and their Unbidden Guests*, p. 132.

† *Journ. of Linn. Soc.* vol. ix. p. 355, and vol. x. p. 468.

Berberis furnishes an instance of rapid motion; for if the stamens be touched at the base of the filament, they instantly spring forward and strike the stigma, having previously lain on the surface of the spreading petals. The effects of the irritation on the filament of *Berberis* has been observed and described by M. E. Heckel.† It appears that the cells of the irritable part are arranged in a parallel manner (the back of the filament being insensible). Their contents are yellow and disseminated throughout the cavity. After irritation, they undergo aggregation and contract into the centre of the cell, and the cell-wall is striated transversely. The cells of the back of the filament are contracted in repose, but extended in irritation.

The stamens of the common Lucerne, *Medicago sativa*, as also of other species of that genus, suddenly curve upwards and remain rigidly fixed in an arched condition, having been previously horizontal.‡

Mr. Darwin has described numerous instances in the family Orchidaceæ, in which the *pollinia*, as of the common *Orchis mascula* and others, or of *Catasetum*, &c., have remarkable powers of movement; in the former cases slow, but in the latter, rapid. In every case there is discernible some special adaptation to the fertilization of the flowers by insect aid.§

Stylidium affords another illustration of rapid motion. In this flower the stamens and style are consolidated into a column, which is curiously bent and hangs over one side of the flower. If it be touched near the base, it instantly flies over to the other side. A very similar motion occurs in the pistil of *Maranta*.

Some flowers have the stamens in a certain position on first expanding, but they take up another position subsequently. This I found to be the case with *Alisma Plantago*. On first expanding, the stamens spread out, their anthers being extrorse, but afterwards they curl backwards over the stigmas, thereby in all probability effecting self-fertilization. In several flowers of different species, the filaments retire after the anthers have shed the pollen or fallen off, as in the lemon-scented and oak-leafed *Pelargoniums*, and in *Teucrium Scorodonia*, or wood-sage. In both of these, the anthers mature some time before the stigmas, and assume a position adapted to insects to transport their pollen. Subsequently the filaments bend away, and the styles now take up the same position that the filaments had previously held (Pl. V. figs. 19–22).

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* Baxter's *British Flora*, vol. i. (70).

† *Bull. Soc. Bot. Fr.*, 1874, vol. xxi. p. 208.

‡ *Journ. of Linn. Soc.* vol. ix. p. 327.

§ See *Fertilization of Orchids.*

Space will not allow further descriptions; but enough has now been said to show how extensive and varied are the movements effected by the different organs of plants, and the advantages accruing to them by possessing such powers of motion.

EXPLANATION OF PLATE V.

Figs. 1, 2, 8–16, *after Darwin.*
Figs. 4–7, 19–22, *ad nat.*
Figs. 17, 18, *after Kerner.*

FIGS. 1 and 2. *Zea mays;* radicles excited to bend away from little squares of card attached to one side of their tips. In fig. 2, the card has been rubbed off.

FIG. 3. A radish, of which the radicle had tied itself into a knot, probably in the same manner as in the case described and figured by Mr. Darwin, by the apex continually moving away from some obstruction, until it had passed through the loop, as seen in fig. 2. Reduced one-half.

FIG. 4. Pendulous head of florets of *Trifolium subterraneum;* the fertile flowers reflexed, the abortive still erect, forming a vertical cone.

FIG. 5. The same, with abortive florets, now developed and becoming reflexed.

FIG. 6. A barren floret, enlarged. It consists of the rigid 'calyx-tube,' supporting claw-like sepal lobes.

FIG. 7. Multicellular hairs from the calyx, which exhibit aggregation under the process of absorption of nitrogenous matters. Figs. 4–7 enlarged.

FIG. 8. Leaf of *Averrhoa bilimbi,* asleep, with its leaflets pendulous; much reduced.

FIG. 9. Leaf of *Lupinus pilosus* seen vertically from above, by day.

FIG. 10. Leaf of the same seen laterally, at night. Figs. 9 and 10 reduced.

FIG. 11. Leaf of *Melilotus officinalis,* during daytime.

FIG. 12. Leaf of the same, asleep.

FIG. 13. Leaf of same, asleep, seen vertically from above. Figs. 11–13 enlarged.

FIG. 14. Leaf of *Trifolium repens,* during the day.

FIG. 15. Leaf of same, asleep, at night.

FIG. 16. Leaf of *Coronilla rosea,* asleep, with its leaflets thrown upwards.

FIG. 17. Flower of *Silene nutans,* by night, the petals unrolled.

FIG. 18. The same, by day, the petals being rolled up.

THE CENTENARY OF THE DISCOVERY OF URANUS.

BY W. F. DENNING, F.R.A.S.

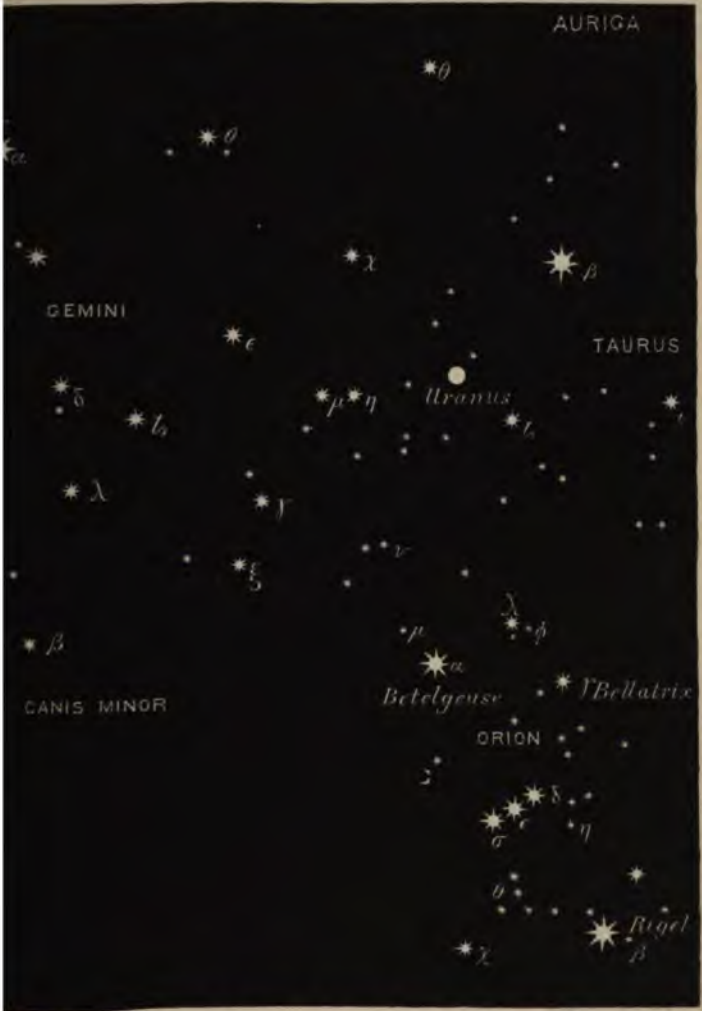
THE year 1781 was signalized by an astronomical discovery of great importance, and one which marked the epoch as memorable in the annals of science. A musician at Bath, William Herschel by name, who had been constructing some excellent telescopes, and making a systematic survey of the heavens, observed an object on the night of March 13 of that year, which ultimately proved to be a large planet revolving in an orbit exterior to that of *Saturn*. The discovery was as unique as it was significant. Only five planets, in addition to the Earth, had hitherto been known; they were observed by the ancients, and by each succeeding generation; but now a new light burst upon men. The genius of Herschel had singled out from the host of stars which his telescope revealed, an object, the true character of which had evaded human perception for thousands of years!

The centenary of this remarkable advance in knowledge naturally recalls to mind the circumstances of the discovery, and makes us inquisitive to know what new facts have been gleaned of Herschel's planet now that a hundred years have passed away and we are enabled to look back and review the vast amount of labour which has been accomplished in this wide and attractive field of astronomical research. We may learn what new features have been discerned of the new body, and what additional discoveries in connexion with other planets, unknown in Herschel's day, have been effected by aid of the powerful telescopes which have been devoted to the work. We do not, however, intend dealing with the general question of planetary discovery, for at a glance we are impressed with its magnitude. While a century ago five planets only were known, we now have some 230 of these bodies, and the stream of discovery flows on without abatement through each succeeding year.

The detection of *Uranus* seems, indeed, to have been the prelude to many similar discoveries, and to have offered the incentive to greater diligence and energy on the part of observers in various parts of the world.

Many great discoveries have resulted from accident; and the leading facts attending that of *Uranus* prove that in a large measure the result was brought about in a similar way. Herschel, as he unwearyingly swept the heavens night after night, was in quest of sidereal wonders—such as double stars and nebulæ, and he happened to alight upon the new planet in a purely chance way. He had no expectation of finding such a remarkable object, and indeed, when he had found it, wholly mistook its character. There could be no doubt that it was a body wholly dissimilar to the fixed stars, and it was equally certain that it could not be a nebula. It had a perceptible disc, for when it had first come under the critical eye of its discoverer he had noticed immediately that its appearance differed widely from the multitude of objects which crossed the field of his telescope. He had been accustomed to see hosts of stars pass in review, and their aspect was in one respect similar, namely, they were invariably presented as points of light incapable of being sensibly magnified, even with the highest powers. True there was a great variety of apparent brightness in these objects, and a singular diversity of configuration, but there was no exception to the invariable feature referred to. The point of light was constant, and no striking exception was anticipated until one night—March 13, 1781—Herschel being intently engaged in the examination of some small stars in the region of *Gemini*, brought an object under the range of his telescope, which his eye at once selected as one of anomalous character. Applying a higher power, he noticed that it exhibited a planetary disc, but his instrument failed to define it with sufficient distinctness, and hence he became doubtful as to its real nature. The object was found to be in motion, and subsequent observations led him to the assumption that it must be a comet of rather exceptional type. This appeared to be the best explanation of the strange body, for history contained many records of curious comets, some of which were observed as nearly circular patches of nebulous light, and probably of similar aspect to the object then visible; and apart from this, it must be remembered that the idea of a large planet exterior to *Saturn* was a fact of such momentous import, that Herschel, with a due regard to that modesty which accompanies true genius, refrained from attaching such an interpretation to his observations. He was content to direct the notice of astronomers to it as a phenomenon requiring close attention, and suggested that it might be a comet in conseof its motion and the faint, and somewhat ill-defined ter of its appearance.

m the earliest ages five planets only were known, and



. Approximate place of *Uranus* amongst the stars at its discovery on March 13, 1781.

scovery of another large planet beyond the sphere of must at once revolutionize existing ideas as to the range solar system, and immediately take rank as a scientific *of equal interest to* the discovery of the moons of Jupiter or the rings of *Saturn*, which each in their day impressed men with new ideas of the celestial mechanism. But the truth could not long be delayed. The new body being watched, and its orbit rigorously computed from a series of observed positions, revealed its true character, and Herschel was awarded the honour due to the author of a discovery of such importance. His diligence and pertinacity alone had enabled him to search out from amongst the multitude of stars thickly strewn over the firmament, this unknown and well-nigh invisible planet, which during all the preceding years of the world's history had eluded human perception. Men had been all unconscious of its existence, as it had been slowly completing its circuits around the Sun, obedient to the same laws as the other planets of the solar system, and awaiting the hour when the unfailing eye of Herschel should introduce it as the faint and far-off planet girding our system within its expansive folds.

As soon as the existence of the new orb was confirmed, and the fact rendered indisputable, the question naturally arose whether it had ever been seen in former years by the authors of star-catalogues, who could hardly have overlooked an object like this, though its planetary nature had manifestly escaped detection. It was just perceptible to the naked eye, shining like a star of the sixth magnitude, and ought to have been distinguished by those who had reviewed the heavens with the purpose of determining and mapping the positions of the stars. Reference was therefore made to the chief catalogues, when it was found at once that the planet had been unquestionably observed by Tobias Mayer, Le Monnier, Bradley, and Flamsteed. It was several times noted by these observers: by Le Monnier no less than twelve times, and by Flamsteed on six occasions; and it is remarkable that in every instance its true character escaped detection. Neither its special appearance nor its motion attracted attention, so that it was merely catalogued as an ordinary fixed star. Thus Herschel was not anticipated in his discovery. It remained for him, in 1781, to note its exceptional aspect, and to specify it as an object requiring critical investigation. But the early observations above alluded to served a useful purpose in testing the accuracy of the computed orbit, for without waiting many years to compare the theoretical and observed positions, astronomers had, in these old records, a reliable series of points, through which the previous course of the planet could be traced.

The calculations showed that its mean distance from the sun was some 1,750,000,000 miles, and that a revolution was completed in about eighty-four years. It was also found to be a very large planet, greatly exceeding either *Mercury*, *Venus*, the *Earth*, or *Mars*, though considerably inferior to either *Jupiter* or *Saturn*.

Here, then, was a discovery of the utmost importance, and one of the most salient additions to our knowledge which the telescope had ever achieved. The new planet was now definitely assigned its proper place in the solar system, and was regarded as of equal significance with the old planets. True, the new planet of Herschel could not be compared as regards its visible aspect with the other previously known members of our system, but it was nevertheless an object of equal weight. Its vast distance alone rendered it faint. It formed one of the constituent parts of the solar system, which, though separated by immense intervals of space, are yet coherent by the far-reaching effects of gravitation. There is, indeed, a bond of harmony between the series of planetary orbits, which exhibit a marked degree of regularity in their successive distances from the Sun; and though they are not connected by any visible links, they are firmly held together by unseen influences, and their motions are subject to certain laws which have been revealed by centuries of observation.

The question of suitably naming the new planet soon came to the fore. Herschel himself proposed to designate it the *Georgium Sidus*, in honour of his patron, George III., just as Galileo had called the satellites of *Jupiter* the *Medicean stars*, after Cosmo de Medici. But La Place proposed that the planet should be named after its discoverer; and thus it was frequently referred to as *Herschel*, and sometimes as 'the Herschelian planet.' Astronomers on the Continent objected to this system of personal nomenclature, and argued that the new body should receive an appellative in accordance with those adopted for the old planets, which had been selected from the heathen mythology. Several names were suggested as suitable (on the basis of this principle), and ultimately the one advanced by Bode received the most favour, and the planet thereafter was called *Uranus*.

The varying positions of the new body as observed on successive nights, were determined by comparisons with a group of six small stars, termed by Herschel α, β, γ, δ, ε, ζ, and afterwards formed into a constellation under the designation of '*Britannia*,' though it does not appear that this little asterism is acknowledged as one of our constellations. Its position is about midway between *Taurus* and *Gemini*, and the following are the principal stars computed for 1881·0, as given by Mr. Marth:—

Star.	Magnitude.	Right ascension. h m s	Declination.
α	9·0	5 42 6·06	23° 35′ 6″·7 N
η	8·7	5 43 17·82	23 26 7·2 „
θ	8·8	5 44 0·99	23 53 30·8 „
ε	8·8	5 45 40·68	23 34 46·8 „

The stars are therefore merely telescopic, and are confined to a small area of space, so that the propriety of adopting the group as a distinct constellation is very questionable. Their positions, close to *Uranus* at the time of its discovery, and the fact that the planet's motion was detected by means of comparisons with them, has given to these stars an historical interest which in future years must often attract the student to their re-observation. But it would be unwise, as forming a bad precedent, to accept a group of stars of this inferior type as meriting to rank amongst the old constellations, when we have numbers of richer groups, situated on their confines, which first deserve such a distinction. However special or unique the circumstances connected with certain telescopic stars may be, and however necessary it may appear to signalize them by a specific title, we are inclined to question the adoption of such means as likely to exercise a wrong influence, inasmuch as it may hereafter originate further innovations of a similar character, and ultimate complications will be certain to arise.

Soon after the discovery of *Uranus*, it was suspected that the planet was encircled, like *Saturn*, by a luminous ring, but on subsequent observation this was not confirmed; and no such appendage has ever been revealed in the more perfected instruments of our own times. Indeed, if *Uranus* displays a peculiarity of constitution in any way analogous to the ring-system of *Saturn*, it must be of the most minute character so as to have thus evaded telescopic scrutiny during a hundred years.

The discovery soon attracted the notice of royalty, and the reigning sovereign, George III., anxious to practically express his appreciation of the valuable labours of Herschel, awarded him a pension of 200*l.* a-year and furnished him with a residence at Slough, near Windsor, and the means to erect a gigantic telescope with which he might be enabled to continue his important researches. This instrument consisted of a reflector on the 'Front-view' construction, with a speculum 4 feet in diameter and of 40 feet focal length. Upon its completion, Herschel immediately began to observe the region of the new planet with the idea of discovering any satellites which might belong to it, for analogy suggested that it was surrounded by a numerous retinue of such bodies. He was soon successful, for, on the night of January 11, 1787, he saw two minute objects near the planet, which renewed observations revealed to be satellites; and he detected two additional ones in 1790, and two others in 1794, making six in all. But the observations were of extreme difficulty. The path of the planet frequently passed near minute stars, and it became hard to distinguish between them and the suspected satellites. Herschel, however, considered he had obtained conclusive evidence of the existence ix satellites with sidereal periods ranging from $5^d 21^h 25^m$ to $^d 16^h 39^m$, and his means of observation being much superior ıose possessed by any of his contemporaries it was impossible ave corroborative testimony.

The matter was thus allowed to rest until the middle of the ent century, when Lassell, in the pure sky at Malta, en- oured to re-observe the satellites with a 2-foot reflector. instrument was considered superior to Herschel's telescope; the atmosphere at this station being decidedly more suit- for such delicate observations than in England, it was oved there for the express purpose of dealing successfully objects of extreme difficulty. The results were very im- ant. Mr. Lassell became convinced that *Uranus* had only

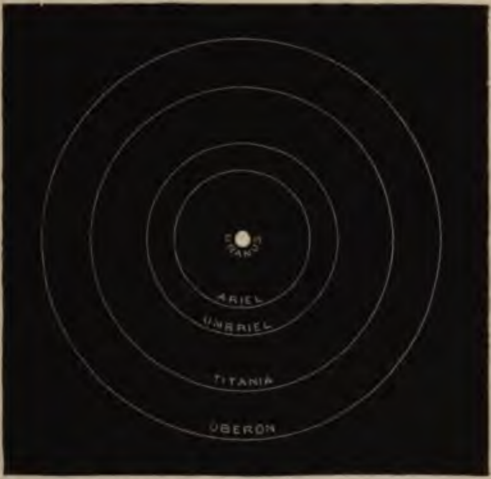


FIG. 2. Orbits of the Uranian satellites.

satellites, and that if any others existed they remained to be overed. Two of these were found to be identical with those by Herschel in 1787, and now called *Titania* and *Oberon*. other two, *Ariel* and *Umbriel*, could not be identified with of those alleged to have been previously detected by schel, so that the inference was that they were new bodies, that the priority of discovery was due to Mr. Lassell; nce it also followed that the older observations were neous, and that in fact Herschel had been entirely mis- n with regard to the four satellites he believed he had cted subsequently to 1787.

n November, 1873, a fine 26-inch object-glass, by Alvan k, was mounted at the U. S. Naval Observatory at Washington, and it was soon employed upon the difficult task of solving the problem as to the exact periods of the Uranian satellites. This was very satisfactorily effected, and with distinct and conclusive favour to Mr. Lassell, whose observations were fully corroborated. Only four satellites could be distinguished by the American observers, and their periods, as computed from a valuable series of measures, agreed with those previously derived at Malta. In Appendix I. to the *Washington Observations* for 1873, Prof. Newcomb gave a valuable summary of results,—the first obtained, be it noted, with that splendid instrument which soon afterwards, in 1877, revealed the satellites of *Mars*,—which included the elements of the satellites of *Uranus* as follows :—

Satellite.	Mean Longitude Epoch 1871, Dec. 31, W.M.T.	Radius of Orbit.	Period of Revolution in days.
I. Ariel	21°·83	13″·78	2·52038
II. Umbriel	136·52	19·20	4·14418
III. Titania	229·93	31·48	7·70590
IV. Oberon	154·83	42·10	13·46327

Speaking of the comparative brightness of the satellites, Prof. Newcomb says :—'The greater proximity of the inner satellites to the planet, makes it difficult to compare them photometrically with the outer ones, as actual feebleness of light cannot be distinguished from difficulty of seeing arising from the proximity of the planet. However, that *Umbriel* is intrinsically fainter than *Titania* is evinced by the fact that although the least distance of the latter is somewhat less than the greatest distance of the former, there is never any difficulty in seeing it in that position. From their relative aspects in these respective positions, I judge *Umbriel* to be about half as bright as *Titania*. *Ariel* must be brighter than *Umbriel* because I have never seen the latter unless it was farther from the planet than the former at its maximum distance. . . . . . I think I may say with considerable certainty that there is no satellite within 2′ of the planet and outside of *Oberon*, having one-third the brilliancy of the latter ; and therefore that none of Sir William Herschel's supposed outer satellites can have any real existence. The distances of the four known satellites increase in so regular a way that it can hardly be supposed that any others exist between them. Of what may be inside of *Ariel* it is impossible to speak with certainty, since in the state of atmosphere which prevails during our winter, all the satellites named disappear at 10″ from the planet.'

Prof. Newcomb mentions that no systematic search for new satellites was undertaken because it must have interfered with the fullness and accuracy of the micrometer measures of the old satellites, which constituted the main purpose of the observations. Some faint objects were occasionally glimpsed near the planet, and their relative places determined, but they were never found to accompany *Uranus*. The fact, therefore, that no additional satellites were discovered is not to be regarded as a strong point in favour of the theory of their non-existence, because the great power and excellence of the telescope was expressly directed to the attainment of other ends; and moreover the season in which the planet came to opposition was distinctly unfavourable for the prosecution of a rigorous search for new satellites. There can, however, be no doubt that the analogies of the planetary systems interior to *Uranus* plainly suggest that this planet is attended by several satellites which the power of our greatest telescopes has hitherto failed to reveal; and that it is in this direction, and that of *Neptune*, we may anticipate further discoveries in future years when the conditions are more auspicious and the work is entered upon with special energy, aided by instruments of even greater capacity than those which have already so far conduced to our knowledge of the heavenly bodies.

Notwithstanding the extreme difficulty with which the Uranian satellites are observed, the two brighter ones, *Titania* and *Oberon*, discovered by William Herschel in 1787, have been occasionally detected in telescopes of moderate power, and identified by means of an ephemeris which has shown that the computed positions approximately agree with those observed. During the last few years Mr. Marth has published ephemerides of the satellites of both *Saturn* and *Uranus*, and many amateurs have to acknowledge the valuable aid rendered by these tables, which supply a ready means of identifying the satellites, and thus act as an incentive to observers who are induced to pursue such work for the sake of the interesting comparisons to be made afterwards. In one exceptional instance the two outer satellites of *Uranus* appear to have been glimpsed with an object-glass of only 4·3 inches aperture, and the facts are given in detail in the *Monthly Notices of the R. A. S.*, April 1876, pp. 294–6. The observations were made in January, February, and March 1876, by Mr. J. W. Ward of Belfast; and the positions of the satellites, as he estimated them on several nights, are compared with those computed, the two sets presenting tolerably good agreement. Indeed the corroborations are such as to almost wholly negative any scepticism, though such extraordinary feats should always be received with caution. In this particular case the chances of being misled are manifold; even Herschel himself fell into error in taking minute stars to be satellites and actually calculating their *periods; so that* when we remember the difficulties of the question our doubts are not altogether dispelled. Extreme acuteness of vision will, in individual instances, lead to success of abnormal character, and certainly in Mr. Ward's case the remarkable accordances in the observed and calculated positions appear to be conclusive evidence that he was not mistaken.

It will be readily inferred that the great distance, and consequent feebleness, of *Uranus* must render any markings upon the disc of the planet beyond the reach of our best telescopes; and indeed this appears to have been a matter of common experience. Though the surface has been often scanned for traces of spots, we seldom find mention that any have been distinguished. Consequently the period of rotation has yet to be determined. It is true that an approximate value was assigned by Mr. T. H. Buffham from observations with a 9-inch reflector in 1870 and 1872, but the materials on which the computation was based were slender and necessarily somewhat uncertain, so that his period of about twelve hours stands greatly in need of confirmation. The bright spots and zones seen on the disk in the years mentioned appear to have entirely eluded other observers, though they are probably phenomena of permanent character and within reach of instruments of moderate size. Mr. Buffham * thus describes them:—

'1870, Jan. 25, 11^{h} to 12^{h} in clear and tolerably steady air; power 132 showed that the disk was not uniform. With powers 202 and 320, two round bright spots were perceived, not quite crossing the centre but a little nearer to the eastern side of the planet, the position angle of a line passing through their centres being about 20° and 200,—ellipticity of *Uranus* seemed obvious, the major axis lying parallel to the line of the spots.

'Jan. 27, 10^{h} to 10$\frac{1}{2}^{h}$; some fog, and definition not good, but the appearance of the spots was almost exactly the same as on the 25th.'

On March 19 glimpses were obtained of a light streak and two spots. On April 1, 4, 6, and 8, a luminous zone was seen on the disk, and in February and March, 1872, when observations were resumed, certain regions were noted brighter than others, and underwent changes indicating the rotation of the planet in a similar direction to that derived from the results obtained in 1870. Mr. Buffham points out that if this is admitted, then the plane of the planet's equator is not coincident with the plane of the orbits of the satellites. Nor need we be surprised at this departure from the general rule, where such an anomalous inclination exists. In singular confirmation of this is Mr. Lassell's observation of 1862, Jan. 29, where he says, "I received an impression which I am unable to render certain of an equatorial dark belt, and of an ellipticity of form."'

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* *Monthly Notices* R. A. S., January, 1873.

Some observations made in 1872–3 with the great six-foot reflector of Lord Rosse, may here be briefly referred to. A number of measures, both of position and distance, of *Oberon* and *Titania*, were made,* and a few of *Umbriel* and *Ariel*, but 'the shortness of the time available (40 minutes) each night for the observation of the planet with the six-foot instrument, the atmospheric disturbance, so often a source of annoyance in using so large an aperture, and other unfavourable circumstances, tended to affect the value of the observations, and to make the two inner satellites rarely within detection.' On Feb. 10, 1872, Lord Rosse notes that all four satellites were seen on the same side of the planet. On Jan. 16, 1873, when definition was good, no traces of any markings were seen. Diameter of *Uranus* = 5″·29. Power 414 was usually employed, though at times the inner satellites could be more satisfactorily seen with 625.

It may be mentioned, as an interesting point, that some fifty years after the first discovery of *Uranus* by Herschel, it was accidentally re-discovered by his son, Sir John Herschel, who recognized it by its disk, and had no idea as to the identity of the object, until an ephemeris was referred to. Sir John mentions the fact as follows, in a letter to Admiral Smyth, written in 1830, August 8: 'I have just completed two 20-feet reflectors, and have got some interesting observations of the satellites of *Uranus*. The first sweep I made with my new mirror I *re-discovered* this planet by its *disk*, having blundered upon it by the merest accident for 19 *Capricorni*.'

In commenting upon the centenary of an important scientific discovery we are naturally attracted to inquire what progress has been made in the same field during the comparatively short interval of one hundred years which has elapsed since it occurred. We have called it a short interval because it cannot be considered otherwise from an astronomical or geological point of view, though, as far as human life is concerned, it can only be regarded as a very lengthy period, including several generations within its limits. Since Herschel in 1781 discovered *Uranus*, Astronomy has progressed with great rapidity, so that it would be impossible to enumerate in a brief memoir the many additional discoveries which have resulted from assiduous observation. A century ago only five planets were known (excluding the Earth), now we are acquainted with about 230 of these bodies; and one of these, found in 1846, is a large planet, whose orbit lies exterior to that of *Uranus*. In fact, the state of astronomical knowledge a century ago has undergone wonderful changes. It has been rendered far more complete and comprehensive by the diligence of its adherents and by the unwearying energy with which both in theory and practice it has been pursued. A zone of small planets has been discovered between *Mars* and *Jupiter* just where the analogies of the planetary distances indicated the probable existence of a large planet. The far-off *Neptune* was revealed in 1846 by a process of analytical reasoning, as unique as it was triumphant, and which proved how well the theory of planetary perturbations was understood. The planet was discovered by calculation; its position in the heavens assigned, and the telescope was then employed merely as the instrument of its detection. The number of satellites which a century ago numbered only ten has now reached twenty; and the discovery in 1877 of two moons accompanying *Mars* shows that the work is being continued with marked success. In other departments we also find similar evidence of increasing knowledge. The periodicity of the Sun-spots, the existence of systems of binary stars, meteor showers and their affinity with cometary orbits, may be mentioned as among the more important, while a host of new comets, chiefly telescopic, have been detected. Large numbers of nebulæ and double stars have been catalogued, and we have evidence every year of the activity with which these several branches are being followed up. In fine, it matters little to what particular department of astronomical investigation we look for traces of advancement during the past hundred years, for it is evident throughout them all, and sufficiently proves that the interest formerly taken in the science has not only been well sustained, but has become more general and popular, and is extending its attractive features to all classes of the community. In Herschel's day, large telescopes were rare. A man devoting himself to the study of the heavenly bodies as a means of intellectual recreation, was considered a phenomenon and, indeed, that appellation might be fittingly applied to the few isolated individuals who really occupied themselves in such work. How different is the case now that the pleasant ways of science have called so many to her side, and so far perfected her means of research as to make them accessible to all who care to see and investigate for themselves the unique and wonderful truths so easily within reach? Large telescopes have become common enough, and there is no lack of hands and eyes to utilize them, nor of understanding, ever ready to appreciate, in sincerity and humbleness, those objects which display in an eminent degree the all-wise conceptions of a great Creator! It is, therefore, a most gratifying sign to notice this rapid development of Astronomy, and to see year by year the increasing number of its advocates, and the record of many new facts gleaned by vigorous observation.

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* *Monthly Notices R. A. S.*, March, 1875.

The character of recent discoveries distinctly intimates that *in future* years some departments of the science will become very complicated, owing to the necessity of dealing with a large number of minute bodies; for the tendency of modern researches has been to reveal objects which by their faintness had hitherto eluded detection. And when we consider that these bodies are rapidly increasing year by year, the idea is obviously suggested that, inasmuch as their numbers are comparatively illimitable, and there is likely to be no immediate abatement in the enthusiasm of observers, difficulties will arise in identifying them apart and forming them into catalogues with their orbital elements attached, so that the individual members may be redetected at any time. In this connexion we allude particularly to minor planets, to telescopic comets, and to meteoric streams, which severally form a very numerous group of bodies of which the known members are accumulating to a great extent. As complications arise, some remedies must be applied to their solution; and one probable effect will be that astronomers will be induced each one to have a speciality or branch to which his energies are mainly directed. The science will become so wide in its application and so intricate in its details, that it will become more than ever necessary for observers to select or single out definite lines of investigation and pursue them closely; for success is far more likely to attend such exertions than those which are not devoted to any special end but employed rather in a general survey of phenomena. We have already before us some excellent instances in which individual energies have been aptly utilized in the prosecution of original work in some specific branch of astronomy, and we are strongly disposed to recommend such exclusive labours to those who have the means and the desire to achieve something useful. Observers who find one subject monotonous and then take up another for the sake of variation, are not likely to get far advanced in either. In the case of amateurs who use a telescope merely for amusement, and indiscriminately apply it to nearly every conspicuous object in the firmament without any particular purpose other than to satisfy their curiosity, the matter is somewhat different, and our remarks are not applicable to them. We refer more pointedly to those who have a regard for the interests of the science and whose enthusiasm enables them to work habitually and with some pertinacity.

History tells us that the Great Alexander wept when he found he had no other worlds to conquer, and we fear that some astronomers will lament that they have little prospect of discovering anything fresh in a sphere to which our giant telescopes have been so often directed, but this is founded on a palpable misconception. Certain objects, such as comets for example, do not require great power, and the revelation of new meteor-showers is entirely a question for the naked eye. In fact, it may be confidently asserted that observations undertaken with energy and persistency will, if rightly directed, more than compensate for defects of instrumental power. It is true, however, that in certain quarters we must look to large instruments alone for new discoveries. It would be useless searching for an ultra-Neptunian planet, or for additional satellites to *Uranus* or *Neptune*, or for the materials to determine the rotation periods of these planets, with a small telescope. Every observer will find objects suited to the capacity of his instrument, and he may not only employ it usefully, but possibly make a discovery of nearly equal import with that which rendered the name of Herschel famous a century ago.

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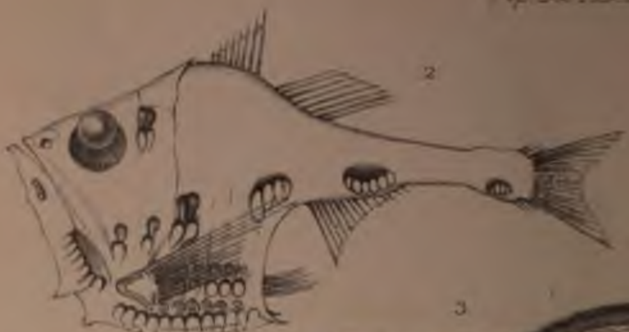

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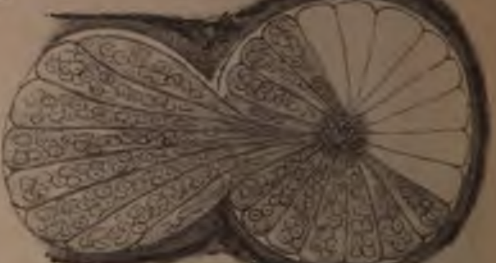

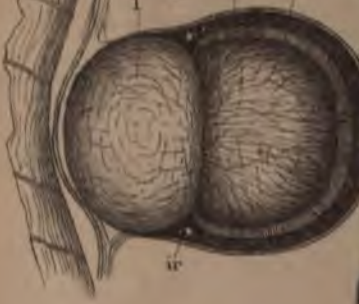

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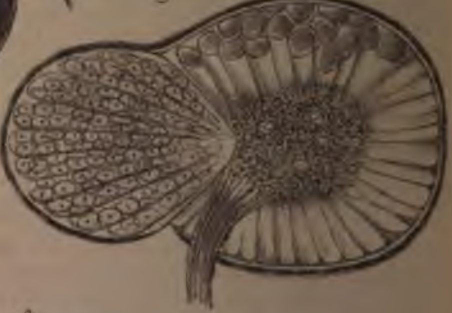

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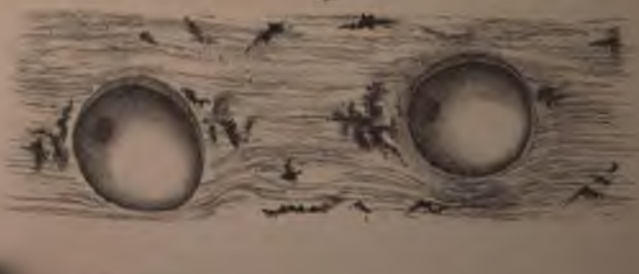

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EYE-LIKE ORGANS OF FISHES.

THE EYE-LIKE SPOTS IN FISHES.

By Professor F. JEFFREY BELL, M.A.

[Plate VI.]

WE are so naturally inclined to take ourselves as the norm or standard in animal organization, that we are almost too easily astounded by any difference in the arrangement of parts or organs which are found in ourselves. With none, perhaps, is this more the case than with the eye; we are so accustomed to associate a pair of eyes with every living creature, that blindness on the one hand, or a number of eyes on the other, excites more astonishment than the reduction or multiplication of any other part. A child in spectacles is the object of a not always respectful pity; and the poet to heighten the horror of his Cyclops makes him one-eyed.

> 'Ingens, quod torvâ solum sub fronte latebat;'*

And Milton has put much the same feeling into words when he makes Samson say,—

> 'Why was this sight
> To such a tender ball as the eye confined,
> So obvious and so easy to be quenched;
> And not, as feeling, through all parts diffused,
> That she might look at will through every pore?'

A survey, however, of the more important divisions of the animal kingdom, need not be very elaborate to convince us that the arrangement of parts which obtains in the case of our own eyes, and, in broad outline, in that of all the other vertebrated animals, is by no means similar to what we find in the Octopus, the Crayfish, or the marine Worm; yet all these three representatives of these different types have eyes of very considerable complexity and of very different ancestry; and all exhibit obedience to the same physical laws, and present similar optical conditions.

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* 'With sharpened point that eyeball pierce,
Which 'neath his brow glared lone and fierce.'
Conington.

Simpler than these are the eyes of the Star-fishes, and still simpler those of the Leech and of the lowlier Worms, some of which have, as it seems, nothing more than mere pigmented spots, the nervous supply of which has still to be worked out.

But the diversity does not end here: the Leech has ten 'eyes.' Some of the marine Worms that live in tubes have a number of eyes on the delicate respiratory filaments which project from their anterior end; some have eyes at the hinder end of their body; and *Polyophthalmus* is a veritable Argus, for in addition to the eyes in its head there is a pair on every segment of the body.

Where so much variation is seen it is only natural to expect that external conditions will be found to have very considerable influence. We all know that the Earth-worm is without eyes; and to the various known examples of the reduction of the eyes in such burrowing animals as the mole, and the complete blindness of some that live in caves, such as the blind-fish (*Amblyopsis*) of the Mammoth Cave of Kentucky, and the amphibian *Proteus* of the caves of Carniolia, there have lately been added two blind snails from the just-named Austrian grotto.

The great increase in our knowledge of animals which has resulted and is resulting from the deep-sea explorations which have been carried on with such activity during the last few years, is very strikingly shown in the case of the organ of sight. In one of the earliest of these—that of the Porcupine—a crustacean (*Ethusa granulata*), was discovered living at various depths; specimens taken in shallow water were found to have eyes of the usual character; those which were brought up from depths varying between 110 and 370 fathoms had the ordinary eye-stalks, but the place of the eye was taken by a calcareous knob; the condition was one to which the words of Mr. Darwin may well be applied, 'The stand for the telescope is there, though the telescope with its glasses has been lost.' Specimens of the same species taken from still greater depths (from 500–700 fathoms) exhibited a still more remarkable change: the eye-stalk was found to have lost its special character, and to have been converted into a pointed rostrum. So again a number of new blind Crustacea have been lately described by M. Milne-Edwards from the Gulf of Mexico. Did the matter end here it would be easy enough to ascribe the changes to the disuse of the eye, owing to the want of light at so great a depth. Fortunately, however, naturalists were spared too hasty a generalization, for from the same depths the dredge of the same ship brought up specimens of the genus *Munida*, in which the eyes were developed to a very great size.

What is true of Crustaceans is true also of fishes, as the following quotation from Dr. Günther will show better than any words of ours: 'The organ of sight is the first to be affected by a sojourn in deep water. Even in fishes which habitually live at a depth of only eighty fathoms, we find the eye of a proportionately larger size than in their representatives at the surface. In such fishes the eyes increase in size with the depth inhabited by them, down to the depth of 200 fathoms, the large eyes being necessary to collect as many rays of light as possible. Beyond that depth small-eyed fishes as well as large-eyed occur, the former having their want of vision compensated for by tentacular organs of touch, whilst the latter have no such accessory organs, and evidently see only by the aid of phosphorescence. In the greatest depths blind fishes occur with rudimentary eyes and without special organs of touch.'*

Interesting as these cases are, and that the more because there still remains to be solved the interesting problem raised by two lines of development being followed by animals living under apparently exactly the same conditions, and starting from exactly the same point, the ordinary vertebrate or crustacean eye, we must turn from them to give an account of a structural arrangement found in various fishes, which will be seen to be not distantly connected with the question of the phosphorescent light of the deep-sea. Of one of these fishes the lamented Willemoes-Suhm wrote home, 'Wie ein leuchtender Stern hing einer im Netz, als er Nachts herauf kam.'

Among the bony fishes (*Teleostei*), and in that division which is distinguished by having the air-bladder communicating by an air-duct with the anterior portion of the intestine (*Physostomi*), and especially among the members of the group which always, or generally, live at great depths, there are sometimes found—as for example in *Scopelus* or *Astronesthes*—one or two rows of small rounded bodies, which are chiefly distributed along the sides of the body, although sometimes, as in the latter of the two just-named genera, they are also very well developed in front of the proper eye. In *Ipnops*, a form first collected by the officers of the *Challenger* exploring voyage, and which is placed by Dr. Günther next to *Scopelus*, there are indeed none of these bodies; but the eye of this fish appears to have lost its function and to have taken on that of a phosphorescent organ.

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* To this may be added the case of the Decapod Crustacean, *Willemoesia* (so named after the late naturalist Willemoes-Suhm, of the *Challenger* Expedition); one species of this form was dredged in 1900 fathoms, and the genus is distinguished by having neither eyes nor eye-stalks.

Although it is only quite lately that these organs have attracted any especial attention, their presence in *Scopelus* and other forms was long ago noted by various observers. It was in the year 1839 that the Italian naturalist, Cocco, of Messina, had his attention directed to them, and he published figures and descriptions of the forms which live in the Mediterranean; ten years later a number of the species which possess these structures were treated of in the twenty-second volume of that monument of industry and research, in which Cuvier and Valenciennes systematized our knowledge of the group of fishes. But the work begun by the two, and carried on after Cuvier's death as far as the twenty-second volume, could not, even with its scope, deal in detail with all the parts of every fish; and even had that been possible, the means of investigation which were to hand would doubtless have been insufficient for a complete and correct understanding of the organization of these parts. Modern methods in histology were above all things necessary: even in the case of the human eye, we know that much of what is now the common property of all students resulted from the studies of Max. Schultze in the middle years of the seventh decade of this century. He who will turn to the article on the eye which appears in Stricker's *Handbook of Histology* will see how much has been done since the year 1850; and we have only to compare the first edition of so easily accessible a book as Prof. Huxley's *Lessons in Elementary Physiology* (1866) with the second, which appeared two years later, to recognize at once how all our exacter knowledge of these complicated nervous structures is due to the improved methods of comparatively recent times.

Understanding, then, the real position of affairs, it will be easily seen that the investigation of the minute structure of these eye-like organs offered quite recently an altogether unexplored field of research. With the exception of a short notice by Prof. Leuckart in the year 1865, which led to the belief that the parts in question were accessory organs of sight, nothing seems to have been published with regard to them till the year 1879, when Dr. M. Ussow, of the University of St. Petersburg, gave to the world an account of his researches. These had been undertaken on twelve species, belonging to the seven genera, *Astronesthes*, *Stomias*, *Chauliodus*, *Scopelus*, *Maurolicus*, *Gonostoma* and *Argyropelecus*, all of which are small, and most of which live in the Mediterranean. He pointed out that the organs might be arranged in two series, one of which he regarded as forming accessory eyes, and the other as special glandular organs, and he insisted on the fact that, though they are both arranged in just the same way, the two sets are never found in the same fish.

Before proceeding any further with Dr. Ussow's views, it is ecessary to state that early in the year 1880 Dr. Günther gave o the Linnean Society an account of these bodies, in which he xpressed his belief that these organs were producers and not eceivers of light; and in his introduction to the *Study of ishes*, published last year, the ichthyologist just named speaks hus in the very last paragraph of his book: 'Many pelagic nd deep-sea fishes are provided with peculiar small round rgans of a mother-of-pearl colour, distributed in series along he side of the body, especially along the abdomen. Some oologists consider these organs as accessory eyes, others (and t appears to us with better reason) as luminous organs. They eserve an accurate microscopic examination made on fresh pecimens; and their function should be ascertained from bservation of the living fishes, especially also with regard to he question, whether or not the luminosity (if such be their unction) is subject to the will of the fish.'

One of the required conditions has already been fulfilled. rof. Leydig, of Bonn, has just published a small volume, illusrated by ten octavo plates, in which he deals in great detail ith what he has been able to observe in the spirit specimens f ten species, one of which belongs to a genus (*Ichthyococcus*) ot examined by Ussow; to this work we shall shortly return. or the moment the prior studies of the Russian naturalist laim our attention.

All, however, agree generally in their account of the arrangement of these spots; ordinarily they extend from the pectoral ins to the tail, and, according to Ussow, they are covered by cales; sometimes they are found in front of the eye (Pl. VI. ig. 2), on the branchiostegal rays, and on some of the adjoining ones; but these anterior spots never exhibit the same striking egularity of arrangement as do those on the abdomen. They ary considerably in the number present, but an average is ound to give the astonishing figure of something like three undred. In *Chauliodus* Leydig found some thousands of these pots. The most simple seem to be found in *Astronesthes*, a enus which did not come under Prof. Leydig's examination; hese have the form of a biconvex lens, which is strongly swollen nternally, and has on its outer surface a slight ridge. A layer f connective tissue invests the whole of the organ, and is lothed internally by a layer of brown pigment cells. At the entre of the outer surface there is a small circular orifice, rom which the deposit of pigment is absent. Just below this rifice there is a lens, which is regarded by Dr. Ussow as exactly omparable to the crystalline lens of many invertebrate animals; nd behind this, and between it and the base of the organ, here is a space of some size which is filled with a watery fluid ('aqueous humour'). On the inner wall of this chamber there is a layer of hexagonal plates, transparent and uncoloured, exhibiting a very regular concentric arrangement, and containing a protoplasmic mass which is longitudinally striated. These plates are looked upon by the author as representing the retina, and as the end-organs of nerve-fibres.

At first sight there can be no doubt that the general characters of an eye are very well represented, but Prof. Leydig, as we shall shortly show, is able to give a very different explanation of the real meaning of these structures.

Let us, however, next take the much more complicated case of *Stomias* (Pl. VI. fig. 1); here the ellipsoidally-shaped eyes are divisible into two unequal portions, the smaller of which is directed forwards, and is applied to the inner surface of the scales, while the other lies among the superficial muscles; the two portions are separated by an extremely delicate partition, and the anterior chamber is filled by an oval and perfectly transparent body (*l*), while the posterior contains a clear and gelatinous substance (*x*), just as in the preceding case of *Astronesthes*; the whole organ is invested by a pigmented layer (*p*), which is only feebly developed on the walls of the anterior chamber, and seems to form, though here we must say we think the resemblance is pressed a little too far, a kind of iris-like diaphragm (*ir*) between the fore and hinder divisions of the organ. It is curious, indeed, that hexagonal transparent cells, apparently made up of prismatic rods, should lie on the inner face of this coloured layer, but we must own that they hardly seem to us to have the distinct retinal arrangement which is assumed for them.

Chauliodus is reported to have larger eye-like organs than the two genera already examined; but it is not necessary to deal in detail with this case, for it appears to us that a mere consideration of the account which is given of it lands us in a peculiarly difficult position. The arrangement of this fish's eye is characterized by the presence of a so-called ciliary body, which is described as being comparable to what obtains in the Cephalopoda.

Here it is most necessary to be exact: are the eyes in question to be compared to those of other Vertebrated animals, or are they to be likened to those of the Invertebrata?

The question is not an unimportant one, for the difference between the two is fundamental and most characteristic, far more important indeed than are most of the distinctions that have been insisted on as justifying that most unfortunate division of the Animal Kingdom into the two great groups of Vertebrata and Invertebrata, which has for long had a disas- effect on the correct understanding of the real relations to one another of the more highly developed animal forms; but which, we may say in passing, owes its existence neither to the laws laid down by Cuvier after a comprehensive survey of the adult, nor by Von Baer after a close study of the characters of developing animals.

To this distinction let us devote a little consideration. When we compare a section of the eye of any invertebrated animal with that of one of the Vertebrata, we find, with other subordinate differences, of which nothing need be here said, this most important and striking one; in the Vertebrata the 'rods and cones,' which are the terminal organs of the optic nerve, are placed quite at the back of the eye, are turned away from the light, whereas in the invertebrate, the Crayfish, for example, we find the anterior part of the end-organ just below the cornea, and as near to the light as possible; not turned away from it, but towards it.

This important difference in the optic arrangements of the adult of the two groups finds, like many other difficult problems, its explanation in the history of the development of the two kinds of eyes. Both have their prime origin in that outermost layer of the embryo—the *epiblast*—which is the veritable mother of all our sensations. In the invertebrate the only change which occurs is that the cells of this layer become modified and elongated; in the vertebrate their history is more complicated; firstly, the layer of epiblast dips in below the level of the back of the body, to form the spinal cord and brain; this set of dipped-in cells get cut off from the exterior, and form a tube of epiblast within the body; from the anterior region of this tube there proceeds an outward growth—the optic vesicle—which grows out towards that thickening of the epiblast which forms the cornea. Thus what was originally outside comes to be inside, and when it grows again to the surface, it does so with its constituent parts turned, as it were, inside out.*

A reference to the subjoined diagrams (p. 228) will perhaps make this difficult point a little clearer. If we take *n* and *r* as representing respectively the layers of nerve-fibres and modified retinal cells, we have in fig. A a representation of what obtains in the Invertebrata and in *B* of what is found in the adult Vertebrate; *C* and *C′* will show the tube of epiblast, while in *D* we see the relation of the two layers in the developing optic vesicle, and *E* shows their position after the 'optic cup' is formed.

The bearing of these considerations is not unimportant; it leads us to ask what is really meant when the spots are spoken as 'eye-like organs?' Are they to be compared to those which are found in the head of the Fish, or are they only of the same simple origin as the eyes of the Invertebrata? This question does not seem to have been fully treated of by Dr. Ussow. If they are only to be compared to those eyes or eye-like organs of which we have already spoken as existing in *Polyophthalmus*, the question not unnaturally arises, may they not have some other function? may it not be that their resemblance, such as it is, to the ordinary eye, is only another illustration of that instructive and frequently recurring phenomenon that, under somewhat similar conditions, parts of animals, or, indeed, animals themselves, though of the most diverse origin, come to have very similar appearances in their adult condition? The uninstructed naturalist finds it difficult to believe that the wing of a bird and of a bat are formed on totally different structural arrangements; some Crustacea look

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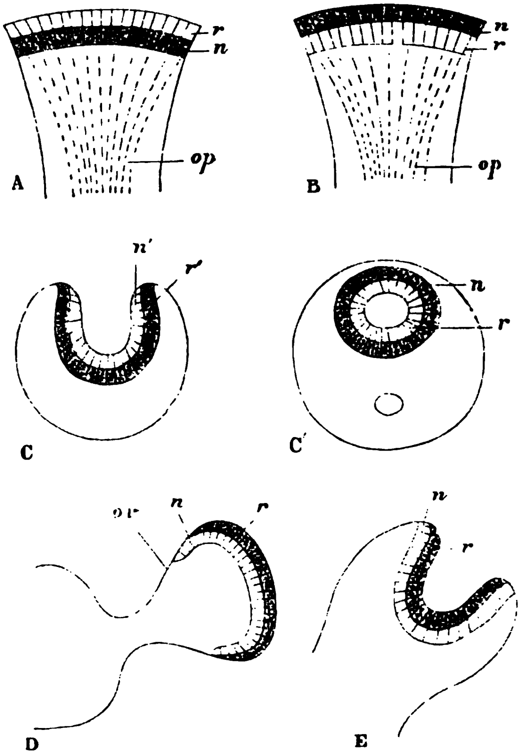
* We owe the first distinct literary statement of this history to Mr. F. M. Balfour, LL.D., F.R.S. (see his *Elasmobranch Fishes*, p. 160).



bivalves than Crayfishes; and the remarkable out-growth from the sides of the skull, which distinguishes the Tortoises, is to be found, to all appearance, in an African Mammal (the Rodent *Lophiomys*), and a lowly Frog (*Pelobates*), found in Central Europe.

Before suggesting any definite answer to the questions thus raised, we must say a few words about the set of organs to which Dr. Ussow does not ascribe any optic function, although he regards them as really belonging to just the same category. As seen in *Scopelus*, they have the form of a pear-shaped sac, the wide end of which lies in the tissues, while the narrower end projects a little above the surface; the latter, which is separated from the part below it by a kind of constriction, contains spherical cells, while the lower portion is filled with cells of a polyhedral form; but there is no central cavity, and there is no kind of orifice. This kind of organ the author looks upon as a gland, and in the more complex case of *Maurolicus* there is no doubt that in what he saw there, there is much to support his view. The 'glands' are elongated and flask-shaped, surrounded for two-thirds of their length by a pigmented membrane; on the inner face of this there is a layer made up of white fibres, and presenting the appearance of a *tapetum*. Here, again, there is no duct to the gland.

We come now to a species which has been examined both by Dr. Ussow and Prof. Leydig—*Argyropelecus hemigymnus*—and it would be interesting, had we space, to compare what these two naturalists have to say about this form. This curious fish (Pl. VI. fig. 2), which is here represented as twice its natural size, is found not uncommonly in the Mediterranean, and is remarkable for the great depth of the anterior portion of its body, and the wonderful way in which it narrows off quite suddenly in the region of the tail. In front of the eye there is one spot, and behind it there are two, and six smaller ones are found on the gill-membrane, and six larger ones are found on the throat; by the gill-cleft we see four, the largest on the body, of which two lie in front and two behind the cleft. At the side of the body, and close to the abdominal profile, there are twelve, which decrease in size from before backwards; and above these there is a second row of six, all of which are of very much the same size. Between the ventral and anal fins there are again four, and behind the anal fin there are six others, of which the smallest are in the middle. Just in front of the tail-fin we find the last quartet of these organs. This gives us fifty-three in all, and as they are paired, we find one hundred and six of these comparatively large spots on the body of this small fish. So much of our account is taken, as is also the illustrating figure, from the description given by Leydig, *who would appear* to agree so far with Ussow, wh says that in this species there are from one hundred to one hundred and ten of these spots; but they differ in the point of covering scales, the presence of which is asserted by Ussow, while Leydig failed to detect their presence. This, however, is not a point of any great importance, and that the more since we know that in the Sternoptychidae, the family to which this fish belongs, the body is either naked or has only very thin and deciduous scales.

Into the further details, as given by either of the histologists already named, it is impossible for us here to enter: the student who desires to know more of the structural characters will gain a quantity of information from their works.*

If we proceed to sum up briefly the general structure of these organs, we find that while Ussow speaks of them as accessory eyes or as glands, Leydig divides them into three groups; (1) eye-like organs, (2) mother-of-pearl-like organs, and (3) luminous organs; of these the second and third forms would seem to be peculiar to the genus *Scopelus.*

The first set are saccular in form and divisible into a bulb, a neck, and an orifice, and this orifice is always directed downwards. From what has been already said we know that they have an investment of brown pigment, a layer with a metallic glitter, a grey inner body, and a surrounding lymphatic space. The investment is derived from the general integument of the body, and the pigment granules are contained in the cells of the underlying connective tissue; the metallic layer consists of iridescent plates, rods, or fibres. The grey inner body is divisible into two portions, the hinder and larger of which fills the sac, while the anterior and smaller occupies the narrower neck. The striated appearance of this part, reference to which has already been made, is due, in Leydig's opinion, to the presence of a framework of connective tissue, which sends rays into or forms a network in it; into this grey part there further proceeds a nerve, the fibres of which probably come into connexion with the contained cells (see Pl. VI. fig. 5). Ussow, as we know, looks upon these organs as having one of two functions, but never both; Leydig looks at the matter a little differently; without affirming that they are one or the other, he says that whatever they are in *Chauliodus*, to which form Ussow ascribes 'accessory eyes,' that also must they be in *Gonostoma*, where the Russian naturalist finds 'glands;' between the two sets there is, in fine, no essential difference.

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* Ussow, M., *Ueber den Bau der sogenannten augenähnlichen Flecken einiger Knochenfische.* Bull. Soc., Moscow, liv. 1879. Pp. 79–115, 4 Pls. *Leydig, F., Die augenähnliche Organe der Fische.* Bonn, 1881. Pp. 100, [illegible] *Pls.*

The mother-of-pearl organs (Pl. VI. fig. 4) are, as the figure shows, appropriately named; they have in all cases an outer brown investment, a metallic layer, a gelatinous internal body formed of connective tissue; they are provided with nerves and blood-vessels and are surrounded by a lymphatic space. The metallic plates are regarded by Ussow as special cells, but Leydig looks upon them as altogether similar to the minute iridescent bodies found on the skin. The gelatinous portion is made up of delicate radiate cells, which give rise to a network, and an intermediate soft substance. No essential difference in structure is presented by the so-called luminous organs.

If we look at the bodies from the point of view suggested by Prof. Leydig, it is impossible not to assent to his conclusion that, whatever they are, they are not sensory in function. At first he was inclined to regard them as belonging to that system of sensory parts which runs down either side of a fish's body, and which is seen from without as a well-marked 'lateral line,' but this was a doctrine which a further examination showed him to be utterly untenable.

After these investigations, Leydig proceeds to sum up his objections to the eye-like organs being regarded as presenting anything truly characteristic of the animal eye; and it must be allowed that he makes some of his points with very great force indeed. The examination of *Chauliodus* alone might leave the investigator with a mind inclined towards the explanation given by Ussow, but a clearer view is gained by testing the doctrine by an investigation into the organ of *Argyropelecus;* here (fig. 3) we see that the 'retinal' nerve-cells are connected with the investment formed by the layer of connective tissue; that in fact they are supporting rather than nervous fibres. So again, the brown pigment at first calls to mind an optic organ, but this brown pigment is more widely distributed through the body of the fish, and especially is it developed in the 'frontal gland' or epiphysis of the brain, where also it leaves a central, clear, unpigmented spot. Nor is this all,—the pigment, as our figure shows, is not laid down continuously, as it is in a choroid, but is scattered at various points. The Bonn histologist carries his merciless criticism yet further; the so-called 'lens,' which so easily has ascribed to it the refractive function, does not lie in the centre but at the edge of the mass which does duty as the vitreous body, and, in addition to its position, its histology prevents us from regarding it as a lens.

One possibility remains; it may be argued that the bodies in question are not to be compared to the ordinary vertebrate eye, but that they are nevertheless terminal sensory organs affected by light; but here, unfortunately, we come upon what is the greatest difficulty of all, the 'pupil,' the 'lens,' and the 'vitreous body' are not turned upwards to the light, but so long as the fish is swimming they look downwards into the deep; and in the case of *Chauliodus* are developed also on the membrane that lines the cavity of the mouth.

After this piece of destructive criticism, it remains for Prof. Leydig to make some suggestion as to what the organs in question can best be compared with. He is of opinion that they bear the closest resemblance to the electric or 'pseudoelectric' organs of other fishes, and he brings many points to strengthen his position. Before we come to any judgment on the matter ourselves, it will be necessary to recall to mind the general structure of an electric organ. These, however much they may vary in details and in their position on the fish that possesses them, always present the following points,—they are richly supplied with nerves, they are surrounded by a layer of connective tissue, which gives rise to a number of 'alveolar' chambers filled with a gelatinous substance. In such a form as the Electric Eel (*Gymnotus*), we find that on the face of each partition which looks backwards, there is a thin homogeneous layer, which is apparently formed of mucous tissue, and on the opposite face, or that which looks forwards, there is a much thicker layer. The nerves passing to and breaking up in this plate, give rise to the electric organ.

When this account is compared with the description that has already been given of the mother-of-pearl organ, we see at once a very considerable resemblance; in both there is a contained mass of gelatinous tissue, in both the same network of connective tissue, and in both nerve-fibres of very much the same character. Nor is this all; in some species, *e.g.*, *Scopelus Rissoi*, there is a spindle-shaped cord or plate, which is formed of extremely delicate granules, and this the author is inclined to regard as comparable to the special *electric plate*. With these essential resemblances, the form is a point of very secondary importance; but even with regard to it Prof. Leydig is ready with an explanation. The rounded form of the mother-of-pearl organs is due to their position on the surface of the body; like the electric organs they would probably become angulated, if they were massed together to form a single body.

Whether they really have the power of developing electricity is a problem that cannot yet be solved; but the question has been put, and it becomes the duty of such naturalists as may have the opportunity to do their best to resolve it.

Nor are we yet in a position to speak dogmatically as to their functions as illuminating organs; no definite phosphorescent organ has ever yet been examined which presented any other contents than fatty or oily matter,* and the cases are rare in which the part which is phosphorescent has not some other and more important function also; where this is not so—as in the instance of the phosphorescent insects—we find, and it is very curious to note this, that the distinguished histologist Kölliker of Würzburg suggested, nearly a quarter of a century ago, that the luminous organs are essentially nervous and present the nearest resemblance to the electrical organs of fishes. This point is not noticed by Leydig, but it would be curious if it should finally turn out that the organs he has been describing with such care, are intermediate between the other two sets. Even if not phosphorescent, it still remains possible that these creatures add to the feeble light of great ocean-depths by reflecting the light that falls on these eye-like organs. We all know how a cat's eye 'shines' in the dark, and most of us, it is to be hoped, know that this is no case of phosphorescence, but that there is a thick layer of wavy fibrous tissue lining the inner face of the eye which reflects the light; reflecting it, by the way, not for the purpose of illuminating the neighbourhood of a nocturnal beast of prey, but reflecting it for the purpose of as many rays as possible passing to the retina. In some of the fishes of which we have made mention, a somewhat similar tapetum has been found, and it is quite possible that that layer does act as a reflector in one of the worst illuminated regions of the habitable globe.

For ourselves, we are inclined to think that the relations of these organs to those with electric properties in other fishes is the most reasonable that has yet been advanced; they may have a secondary illuminating function of some kind, but it was not the necessity for this that first gave rise to their formation. If we assume the correctness of Prof. Leydig's explanation, we have before us a very interesting example of the way in which scientific hypotheses become theories. An obvious external resemblance to secondary eyes led the first naturalist who studied them closely to look on them as accessory organs of sight; a closer and more detailed investigation has shown that this resemblance is purely artificial, and an appeal is now made not to a seeming likeness, but to a more deep-seated similarity,—to one that depends not on the position of rounded fibrous bodies or to a peculiar arrangement of pigment; but to one, in fine, that depends on community of structure, the first and best implement in any investigation into living objects, and the one that, side by side with the history of development, is the only criterion to which the judicious naturalist finds it wise or expedient to appeal.

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* On this point the student is especially to be referred to the various papers of the late Prof. Panceri; for the phosphorescence of fishes, consult 'Panceri' in *Zool. Record* for the year 1871.

EXPLANATION OF PLATE VI.

Fig. 1. Longitudinal section of eye of *Stomias anguilliformis* × 280, showing the inner vitreous body (*x*), and the anterior chamber with its transparent lens (*l*): *r*, retina; *n*, nerve; *p*, pigmented layer; *r*, median constriction. (Ussow, fig. 10, *B*.)

Fig. 2. Figure of *Argyropelecus hemigymnus* × 2. (Leydig, i. 5.)

Fig. 3. Longitudinal section of organ from abdominal region of ditto, magnified highly. (Leydig, iv. 35.)

Fig. 4. Two of the mother-of-pearl organs from the side of the body of *Stomias Humboldtii*, seen in reflected light, slightly magnified. (Leydig, vi. 4[illegible].)

Fig. 5. Organ from the nasal region of *Ichthyococcus ovatus*, longitudinal section, highly magnified, chiefly to show the entrance of the nerve. (Leydig, vi. 5[illegible].)

THE BLACKHEATH SUBSIDENCES.

BY T. V. HOLMES.

MANY readers of the *Popular Science Review* have doubtless heard of the strange subsidences that have appeared on the surface of Blackheath during the last three years, and have attracted so much attention from the suddenness of their appearance, and the mystery surrounding their origin. For when it is remembered that these subsidences suddenly disclosed themselves in the midst of a gravel plateau, every foot of the surface of which is liable to be tested by cricket, golf and football players, schoolboys and holiday-makers, it is evident that nowhere could they have been more unlooked for and alarming.

Having been a member of the executive branch of the committee formed for the purpose of investigating one of these remarkable holes, and the exploration being now finished, I am enabled to give some account of our labours and their results. In addition, I shall review the evidence bearing on the subject, and point out what seems to me to be the most probable conclusion derivable from it. Perhaps the best plan will be to begin with a sketch of the geology of the neighbourhood, a clear understanding of which is absolutely necessary, before giving the details of our workings. The archæological evidence need not be taken into consideration till the geological evidence has first been fully weighed.

The voyager from London to Woolwich cannot fail to notice the range of wooded heights on which Greenwich Observatory stands, which contrasts so much with the low ground bordering the Thames in other directions. This range is flat-topped, and is bounded on the east by the valley of the Darent, and on the west by that of the Ravensbourne; Blackheath occupies the promontory at its western end. At the base of this wooded range lies the Chalk, which is well exposed in the neighbourhoods of Charlton and Lewisham, though elsewhere, for the most part, hidden from sight by the agency of faults or surface deposits. Above the Chalk, along this escarpment, lies the Thanet Sand; then come the Woolwich beds; and, lastly, the Oldhaven or Blackheath pebble beds crown the plateau. Further inland, at and around Shooter's Hill, the London Clay exists in considerable thickness, and extends westward between Kidbrook and Eltham in a slight synclinal fold. At Eltham, the surface is again composed of the Woolwich and Blackheath beds. The newest beds in the district immediately around Blackheath are the gravel capping Shooter's Hill, which is said by Mr. Whitaker * to be intermediate in age between the Lower Bagshot beds and the Boulder Clay, and the gravel and alluvium of the Thames Valley.

A glance at the Geological Survey map, shows that the Blackheath pebble beds and the Woolwich beds crop out on the northern, western, and southern sides of Blackheath. To these may perhaps be added the Thanet Sand, which, though it is shown on the map only on the north and west, and just round the south-west corner, was seen here and there by Mr. Prestwich † at the bottom of the cutting between Blackheath station and tunnel; and I was informed by Mr. Chapman, station-master at Blackheath, that the station there is founded on what can only be Thanet Sand. The dip of the various beds at Blackheath is very slight in amount, and is southerly in direction. In Westcombe Park (east of Greenwich Park) and the adjacent railway cutting, they are very well shown at heights only 15 to 20 feet above their level in the cutting west of Blackheath station, though the distance, measured along a line ranging due north and south, is about a mile and a furlong. It will be seen, therefore, that the geological evidence at Blackheath is much greater in amount than usual, and that it tends to show that the beds are lying nearly level, and are free from faults or disturbances of any appreciable magnitude.

There is evidence, in the appearance of certain spots on Blackheath, that holes like that to be described have disclosed themselves from time to time, and been filled up without any curiosity having been (apparently) excited as to their origin. But in April, 1878, the sudden appearance of a cylindrical hole, about 20 feet deep and from 7 to 8 feet in diameter, made more impression on the minds of the inhabitants of the neighbourhood than had previously been the case. The hole was, however, after remaining open a few weeks, filled up by

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* Whitaker, *Guide to Geology of London*, p. 56 (3rd edit.).

uart. *Journ.* Geol. Soc. vol. x. p. 104.

the Metropolitan Board of Works, without any attempt at exploration. In November, 1880, two other holes suddenly appeared, and the deeper of these two holes is that the examination of which has just been concluded. The Metropolitan Board having stated, in answer to the Astronomer Royal's request that they should explore the first hole, that they had no funds for that purpose, the matter was taken up by the Lewisham and Blackheath Scientific Association, the then President, Mr. J. K. Laughton, R.N., and Mr. H. W. Jackson, F.R.A.S., the Hon. Secretary, being especially zealous in the matter. A small sum was voted by the Association for the exploration, but was soon exhausted; and money coming in but slowly from the neighbourhood generally, April had arrived before the Subsidence committee had received sufficient funds to enable them to continue the work.

The hole which appeared in April, 1878, and that which has just been examined, were almost identical in size and appearance. The last was, when first seen, like a nearly circular shaft with vertical sides, and 18 feet deep.* It was in its longer diameter 7 ft. 8 in., and 6ft. 9 in. in the shorter. When the fallen earth from the bottom was removed, the sides were found to recede till the hole became about 14 feet in diameter, at a depth of about 22 feet. The third hole, that near Eliot Place, was shallower than either of the other two, and somewhat different in shape. The difference, however, was chiefly one of proportion, the shaft-like portion of the hole being very short, and its sides receding more rapidly than in the other two. The Eliot Place hole, after remaining open some months, was filled up by the Metropolitan Board of Works towards the end of April.

During the first brief exploration of the hole, the heap of material at the bottom was carefully examined by Mr. Jackson during its removal, and found by him to correspond exactly to the sand and clay which formed the sides of the hole at and for 7 feet below the surface. On recommencing the work in April, the first shaft, 11 ft. 3 in. by 9 ft., which had been carried to a depth of 16 feet, was considered unnecessarily large, and consequently expensive; and the work was carried on below that depth by means of a shaft 6 ft. by 5 ft. 6 in. Below the surface-material were found Blackheath pebble beds of the ordinary type and orange colour. At a depth of 34 feet water appeared, and continued to fill the hole to about that level during the progress of the excavation, so that a pump became necessary. From 36 to 42 feet, whitish sand and pebbles were brought up. The proportions of sand to pebbles varied considerably, and occasionally differed in a marked manner at different sides of the shaft. The ground below appeared to be loose and disturbed, as was shown by the ease with which an iron rod could be thrust downwards to its full length of 8 feet, compared with the variable but always much greater difficulty attending a horizontal thrust. At the depth of 42 feet, the timber framework of the lower shaft began to settle down on one side very markedly. This settlement was down to the north and north-west, the southern side resting apparently on more solid ground. As the funds at the service of the Subsidence committee were getting very low, and further excavation promised to be a work of great expense if not of danger, it was resolved to cease digging and to try the following plan, which was proposed by Mr. Bond, one of the most active and useful members of the committee.

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* See *Engineer*, Feb. 4, 1881.

Gas-pipes, with an internal diameter of 1½ in., were screwed together and driven down vertically from the bottom of the shaft. All solid matter was kept out of these pipes during their descent by means of a plug with a harpoon-like point, which fitted into the lowest end; the base of this point was of somewhat greater breadth than the external diameter of the pipes. Having reached a depth of 85 feet from the surface, the pipe was raised a few inches and the plug dropped out; then a slender rod, with a kind of spoon at its lower end, was passed down the pipe, and a spoonful of the stuff just outside its lower end brought to the surface. As the pipe was withdrawn, spoonfuls were brought up at intervals of a few inches, so that samples of the material just outside the pipe at various depths between 42 and 85 feet were obtained. Both on driving down and withdrawing the pipe, the resistance encountered varied exceedingly, a progress of 13 feet in one day being followed by one of as many inches the next. Yet there was but little variation in the nature of the material extracted; and it seems likely that the occasional presence of hard nodules, such as may be sometimes found below the well-known shell beds of the Woolwich series, was the cause of the occasional slow progress.

The stuff brought up in the spoon was, between 42 and 50 feet or thereabouts, brown or greenish-brown sand, with but little clay, and occasionally a small pebble. Below 50 feet, no pebbles were brought up, and the proportion of clay to sand increased with the depth, though not with perfect regularity; so, also, did the proportion of dark blue clay to brown. No fragments of shells could anywhere be detected.

It will be well now to consider what evidence we have of the thickness and character of the various beds at Blackheath, and the bearing of this evidence on the results of our exploration. At the house next to the Sun-in-Sands, Shooter's Hill

Road, about three-quarters of a mile E.N.E. of the hole, the Chalk was found to be 109 feet below the surface,[*] the height of the surface being about 150 feet. The surface at the hole is about 132 feet above Ordnance datum, which would give 91 feet as the probable depth of the Chalk there, granting it to be at the same level in the two places, which is probably very nearly the case. About a mile W. of the hole, at Blackheath Hill, the top of the Chalk appears to be about 50 feet above Ordnance datum, which would give about 80 or 82 feet at the hole. The Thanet Sand, which directly overlies the Chalk, was 55 ft. 10 in. at the Brewery at Greenwich Hospital (now Naval College), but at Loampit Hill, Lewisham, is only about 40 feet thick. The Woolwich beds, at Blackheath, judging from the sections now to be seen at Westcombe Park, and from those seen by Prof. Prestwich in the cutting east of Blackheath Station, are a little over 20 feet thick. Greenwich Hospital Brewery gives 23½ feet.[†] The thickness of the pebble beds which form the surface of Blackheath is, of course, variable.

In Westcombe Park the Woolwich beds are not fully seen, but the shell beds are about 5 ft. 6 in. thick, and below them is sandy clay containing nodules of sandy ironstone. It may be interesting to compare the section at Greenwich Hospital Brewery, with that seen by Mr. Prestwich east of Blackheath Railway Station.[*]

BLACKHEATH RAILWAY CUTTING.

Blackheath pebble beds, 10 *to* 12 *feet.*

		Feet.	
Woolwich beds.	Brownish sand	2	
	Broken-up shells in light-coloured clay, with pebbles	4	Shelly beds.
	Broken-up shells in greenish-grey clay . .	2	
	Light green sandy clays, mottled red and grey .	7	
	Light greenish sands with a few pebbles (bottom bed)	6	
Thanet Sand		21	

GREENWICH HOSPITAL BREWERY.

Blackheath pebble beds.

		Ft.	In.	
Woolwich beds.	Black sand	4	10	
	Blue clay	0	8	Shelly beds.
	Shelly rock	4	0	
	Red clay	6	0	
	White sand	4	0	
	Green sand and pebbles	4	0	
Thanet Sand		23	6	

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[*] Whitaker, *Geol. Lond. Basin*, p. 457. [†] Ib. p. 465. [‡] Ib. p. 124.

In Westcombe Park, water comes out along the line of outcrop of the shelly beds; and Mr. Chapman, station-master at Blackheath, informed me that water, evidently from the same source, affords a supply for the railway station. The water is that which, falling on the permeable pebble beds in the form of rain, is upheld by the impermeable clay of the shell beds below. The shell beds were cut through in making Blackheath tunnel, and the water held up by them keeps the tunnel constantly wet. There can be no reasonable doubt that the water found at a depth of 34 feet in the hole, and which afterwards rose to 33 ft. 1 in. after rains, was water from the base of the pebble beds, and indicated the close proximity of the shell beds below. In the Vale of Health, Messrs. Jackson and Bond found that water was met with at a depth of from 12 to 14 feet. Now as the average height of the surface at the Vale of Health must be about 18 or 19 feet below that of the surface at the explored hole, more than 400 yards N.E. of it, we have herein evidence that the water in both places is from the same source, and that the shell beds lie at each spot at very nearly the same level.

The geological evidence already given shows decisively that the various spoonfuls of material brought up from the hole cannot represent the nature of the beds existing below the surface of Blackheath in undisturbed ground. And we have also learned from it how exceedingly improbable is the existence of any faults or disturbances of the strata there. For while we have more evidence than is usually available in areas of similar size tending towards the last-mentioned view, it is apparent, from the sections given of the constituents of the various beds, that the only clayey beds belong to the Woolwich series and are about 12 or 13 feet thick at the utmost, whereas, judging from the contents of the spoon, clayey beds exist of a thickness of more than 30 feet. In what way, then, can this apparent thickness of clay be accounted for?

The sticky nature of clay, and the small quantity of material brought up may have had some influence in this result, but will not, I think, fully account for it. We have now, in fact, arrived at a point at which it becomes necessary to consider the two views which may be taken as to the origin of these Blackheath subsidences, and their respective probabilities. The first, which may be called the geological view, supposes them to have arisen from the breaking in of the roof of caverns in the Chalk formed simply by the action of water, which, percolating through the overlying tertiary beds, has dissolved away the Chalk in the manner so often seen in the 'sandpipes' of chalk-*pits* and railway cuttings. The second, or archæological view, *is t*[illegible] ubsidences are the result of the action of water on n old shaft leading to a cavern formed (probably in the chalk) y the hand of man. A third view appears to be entertained, which I mention for that reason only, though it has neither evidence, nor even possibility, in its favour. It is that 'the Blackheath subsidences are due to the action of water, the sand being carried off and leaving the pebbles to collapse.' (*Times*, May 12, 1881.) The holders of this view appear to forget that the formation of *natural* underground cavities in highly siliceous sand and gravel is impossible, inasmuch as they, unlike the Chalk, remain utterly insoluble when exposed to the action of ain-water charged with carbonic acid gas. I need therefore ay no more about this third view, but will consider the opinion irst mentioned, the only geological view which deserves the ame.

Allowing 35 feet as the depth at which the top of the shell-eds would be touched, in unbroken ground near the hole, the eds thence to the top of the Thanet Sand must be quite 18 feet hick. The Thanet Sand cannot be less than 40 feet thick, and ay be 5 or 10 feet more. Thus, at the lowest computation, he distance to the Chalk would be 93 feet. Mr. W. Whitaker, owever, who has probably had a more extensive experience of ese beds than any other living geologist, remarks that while few feet only of Tertiary beds above the Chalk give rise to an neven surface, and to pipes, the same process of the dissolving f the Chalk by carbonated water 'when it goes on at greater epths seems to act in a more equal (because in a more constant) ay on the surface of the Chalk, leaving it even.'* Now Mr. Whitaker's experience must have been gained in pits and railay cuttings that would seldom show even 50 or 60 feet above he Chalk, much less 80 or 90 feet. Again, Mr. De Rance bserves† that the permanent water-level in the Chalk at Blackeath is about Ordnance datum, and that the comparatively mall amount of chalk there above this water-level makes it ery unlikely that these subsidences are due to pipes descending ertically into the Chalk. Lastly, our own experience of the ay in which water falling on the surface of Blackheath is held p by the shell-beds below, and thrown out just above their ine of outcrop, is conclusive evidence that scarcely any water an ever get down to the Chalk below at all. All that does do o (artificial holes apart), must fall as rain outside the area of he Blackheath plateau.

An interesting letter appeared in the *Engineer* of Feb. 18, 881, signed Alfred W. Morant, in which the writer gave n account of some remarkable subsidences which appeared in reat numbers many years ago on the sewage farm at Whitingham, near Norwich. He says: 'When the sewage was first allowed to flow over the land, we were astonished day by day to find the fields to be soon covered with circular holes, usually about 3, 4, or 5 feet in diameter and of various depths, the sides always being vertical,' &c. Mr. Morant attributes these subsidences to the excessive quantity of carbonated water suddenly poured over the land, and its effects on the numerous sandpipes which exist in the Chalk of that neighbourhood. On visiting the Whitlingham sewage farm at the end of last March, I saw many of these holes. Those I saw were seldom more than 2 or 3 feet deep, but I was told by the old man who was then engaged in distributing the sewage over the surface, that they often on first appearance were 10 or 12 feet deep, or even more, but that they speedily filled themselves up, to the depth of those I saw, by the tumbling in of their sides. They are certainly very singular and worthy of notice, and are doubtless due to the cause assigned by Mr. Morant. But at Whitlingham we have an immense quantity of carbonated water making its way through loose, highly porous, sandy and gravelly beds, having a thickness of perhaps from 10 to 30 feet, to highly disturbed and probably fissured chalk below.* Another thing which seems to have had, in all probability, a special influence on the production of subsidences at Whitlingham is this. Among the strata overlying the Chalk, there is a bed of pebbles cemented together by oxide of iron and manganese, known locally as 'iron-pan.' Where a sandpipe occurred in the Chalk below, the superior hardness and tenacity of the iron-pan would often be the means of preserving it unbroken and horizontal, while the softer and looser beds beneath the pan had adapted themselves to the shape taken by the sandpipe. A hollow space, shaped like an inverted cone, would be accordingly here and there formed beneath the iron-pan. The form taken by the subsidences at Whitlingham seems to me, therefore, to have been the result of the shape of the hollows probably existing below the pan, which became suddenly filled up by the disintegration of the pan through the influx of sewage water. The anticlinal existing in the Chalk at Whitlingham may very probably reduce the maximum thickness of the overlying beds at the sewage farm to 20 feet or less. But, at all events, the differences between the Blackheath and Whitlingham subsidences must be sufficiently obvious. This Whitlingham case seemed to me, however, well worth examination here, because it is the only one I have met with at all resembling that of Blackheath, which is best explained by the geological theory.

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* *Geology of London*, 3rd edit. p. 32.

† Nature, Feb. 17, 1881.

We now come to the archæological theory of the production of the Blackheath subsidences; and perhaps the best plan will be to give a general account of the archæological evidence bearing on the matter, and then to discuss its applicability to the case before us.

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* [illegible] ports of Papers by Dr. J. E. Taylor, on the 'Beds at Whit-*li* [illegible]. *Mag.* for 1865 (vol. ii.), pp. 324 and 370.

Artificial shafts in the chalk occur in great numbers in parts of Norfolk, Suffolk, Kent, and other counties where chalk abounds. They naturally divide themselves into two groups: those made for the purpose of obtaining chalk and flint (mainly the latter), of which 'Grime's Graves,' in Norfolk, about three miles N.E. of Brandon, furnish by far the best known examples: and those made as places of security, and of warmth in winter, of which the 'Danes' Holes' of Crayford and other places in Kent, near the south bank of the Thames, are the most noteworthy instances.

The ancient pits known as Grime's Graves have been fully described by the Rev. Canon Greenwell, and from his paper on the 'Opening of Grime's Graves,'* I will make a few brief extracts, sufficient to show their general character, and refer those desirous of more details to the paper itself.

The pits are about 254 in number, and are generally about 25 feet apart, covering a space from 20 to 21 acres in extent. They are circular, and vary in diameter from 20 to 65 feet. They have all been filled up to within about 4 feet of the surface. The pit selected for examination was about 28 feet in diameter at the mouth, and gradually narrowed to a width of 12 feet at the bottom, which was 39 feet below the surface. It was cut through a deposit of dark yellow sand, 13 feet thick, which there overlies the Chalk. At the depth of 19½ feet from the top of the Chalk was a stratum of flint of better quality than any nearer the surface. This is called by the present workers —for in this neighbourhood the manufacture of gun-flints still goes on — the 'wall-stone,' and is used for building walls,† though not hard enough for gun-flints. At a depth of 7½ feet below the wall-stone, or 39 feet from the surface, a second bed of flint exists of much better quality, which was, and is now, used for gun-flints. It is probable that the ancient workings were established in this place on account of these qualities in the flint. At the bottom of the shaft this bed of flint, known now as the 'floor-stone,' was worked out as far as the shaft extended, and then galleries were driven out in various directions upon the level of the bed of flint, the overlying chalk being removed to a height of 3 to 5 feet. The galleries vary in width from 4 to 7 feet, and the flint was worked out beyond their sides as far as was practicable without causing the roof to give way. These galleries probably connect all the shafts. There were no steps cut in the sides of the pit, and the workmen either were drawn up by ropes, probably of hide, or ascended by means of a ladder, which would be most probably made by cutting notches in a tree stem. The principal instrument used, both in sinking the shaft and working the galleries, was a pick made from the antler of the red deer, many examples of which were found. When a new pit was sunk, the material excavated went to fill up an old one.

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* *Journ. Ethnological Soc.* Jan. 1871.

† See Mr. S. B. J. Skertchly's *Geological Survey Memoir on Gun Flints.*

Ancient pits of the Grime's-Graves type must be carefully distinguished from certain modern shafts which exist in considerable numbers, and are for the purpose of obtaining chalk where it is some distance below the surface, and yet required for economical purposes. Mr. Aubrey Strahan of the Geological Survey, informs me that there are many such shafts in brickyards in the country west of Windsor; and Mr. H. B. Woodward has lately called my attention to a paper by the late Dean Buckland on the 'Plastic Clay'* (the old name for the Woolwich beds), in which mention is made of a shaft of this character at 'the base of the north-east extremity of Shooter's Hill.' Buckland states that 'in the same field with the clay-pits, and on the north side of them, a shaft is sunk 120 feet to the surface of the subjacent Chalk, which has been extracted to the further depth of 24 feet, being the object for which the shaft was made. He also gives instances of the way in which the 'Plastic Clay' upholds the water in the district, and throws out a line of springs at its outcrop.

Pits of the kind known as Danes' Holes, abound in the neighbourhood of Dartford, Crayford, and Bexley, and near the village of East Tilbury, on the northern bank of the Thames. Similar excavations are said by the author of Murray's *Handbook to Kent* to exist on either bank of the Somme as high as Peronne, in the diocese of Amiens. The tradition of Picardy asserts that 'these caverns were used for the retreat and concealment of the inhabitants in time of war, whence their ordinary name, *les souterrains des guerres*.' Those in the neighbourhood of Crayford are thus described in Hasted's *History of Kent*, vol. i. 1778: 'There are now to be seen, as well on the heaths near Crayford as in the fields and woods hereabouts, many artificial caves or holes in the earth, some of which are 10, some 15, and others 20 fathoms deep. At the mouth, and thence downward, they are narrow, like the tunnel of a chimney, or passage of a well, but at the bottom they are large and of great compass, insomuch that some of them have several rooms or partitions one within another, strongly vaulted and supported with pillars of chalk.' Hasted remarks that ny of those on Dartford Heath 'have been stopped up of ' to prevent the frequent accidents from men and cattle falling into them, and refers to the *Germania* of Tacitus, who describes the Germans as digging out subterranean caves. 'They pile upon them great heaps of dung, as a shelter from winter and as a receptacle for the year's produce, for by such places they mitigate the rigour of the cold. And in case an enemy approaches, he lays waste the open country, while what is hidden and buried is either not known to exist, or else escapes him, from the very fact that it has to be searched for.' (*Transl. Church and Brodribb.*)

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* *Trans. Geol. Soc.* 1st series, vol. iv. p. 277.

Hearing that Mr. F. C. J. Spurrell, of Belvedere, was the chief authority on the subject of these Danes' Holes, I wrote asking where they might best be seen in the neighbourhood of Bexley, having always thought that the Blackheath subsidences were the result of artificial excavations of some kind. Mr. Spurrell replied that Joyden's Wood was a good place, and that he thought the Blackheath subsidences would be found to result from the presence of Danes' Holes there. On the 7th of April he read a very interesting paper on Danes' Holes at the Archæological Institute, in which he stated that they were known to exist as far west as Charlton Park. A remarkable pit, probably originally a Dane's Hole, was discovered in February 1878 at Eltham Park,* and a strange subsidence occurred five years ago in Kidbrook Park Road, on the eastern border of Blackheath. And it is almost certain that the extensive cavern under the Point at the north-west corner of Blackheath should be referred to this class, though it was entered by a gallery driven into the hillside, and not by means of a vertical shaft.

The pits of Joyden's Wood are most abundant in that part called Cavey's Spring. The shafts seen by me were all in Thanet Sand, and were very narrow, though, of course, considerably broader at the mouth than they were five or six feet lower down. I do not think that, except just at the mouth, they were more than 2 feet 9 inches in diameter. Two of them probably communicated with each other below, as they were not more than 80 feet apart. The ground, indeed, for a space of 4 or 5 acres, is covered by bell-shaped pits 8 or 10 feet deep, while here and there appears one of these shafts, sometimes from the bottom of a bell-shaped pit, sometimes not. I was informed that these shafts sometimes appeared suddenly and unexpectedly, and that they were about 70 feet deep. The pit at Eltham Park is 140 feet deep, and has (probably since it was first made) been lined with courses of brick and chalk, so that its present diameter is from 4 feet 1 inch to 4 feet 2 inches. A bed of flint forms the roof of the chamber, which was found, on discovery, to have been used for a considerable time as a cesspool. The existence of both shaft and chamber was unknown to Mr. Jackson, the present proprietor of Eltham Park, till their discovery at the end of a disused drain by a workman sent along the drain to find out the course taken by a quantity of water that had escaped through a leakage. Mr. Petrie notices that five courses of chalk occur in the shaft in the midst of the brickwork, about 47 feet from the surface, and remarks that the chalk for these courses was no doubt procured from the chalk in the shaft 70 feet below, which must have been unlined at the time from these chalk courses downwards. It seems to me most likely that the shaft was first lined when the chamber below was utilized as a cesspool, and that it is impossible that the latter could have been originally constructed for that purpose.

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* See Paper by Mr. W. M. Flinders Petrie, *Proc. Roy. Archæol. Inst.*, March, 1878; and for plan and section of pit, *Engineer*, March 18, 1881.

It will be evident that the Danes' Holes mentioned differ from the other classes of pits in the Chalk not merely in details of construction, but in geological position. For the others are sunk where chalk is at or close to the surface, as at Grime's Graves, or in brickyards, as at Shooter's Hill. But though pits of the Danes'-Hole class are not necessarily found on any one particular horizon, a little consideration shows that the pits at Joyden's Wood, Eltham, and Charlton Park cannot have been intended as pits for chalk or flint. East of Joyden's Wood is a broad spread of bare chalk, yet the makers of the pits there have preferred to go through 40 to 50 feet of Thanet Sand in addition; while Eltham Park, Charlton Park, and Blackheath, all stand on the Blackheath Pebble Beds, and could never have been the sites of brick or tile works. In addition, there is plenty of chalk near at hand, both at Charlton and Blackheath, north and west of the plateau.

Thus by a process of elimination ending in the 'survival of the fittest,' pits of the Danes'-Hole class remain as the only probable explanation of the Blackheath subsidences. A little consideration will show that the inconvenience as regards the water at 34 feet, which was so serious a matter to us, with our large shaft and shattered ground, would not be very formidable to men sinking a shaft of 2 feet 9 inches in unbroken material. A relative who has seen much of primitive mining in Bolivia at once suggested to me that they would soon stop the percolation of the water by claying the sides for the two or three feet in which such protection was necessary. The pebble beds would probably stand very well in the shaft if subject only to the gentle percolation of water, and shielded from the direct action of rain. Of course a shaft in such strata would be ed and descended by means of a notched tree-trunk, or of two or three spliced together, as I am informed is the usual mode in Bolivia.

It seems likely that the upper third of the narrow shaft became filled up mainly by the falling in of the pebble beds, leaving the lower two-thirds almost or quite empty. (Possibly a very slight hollow without any outlet, about 30 feet in diameter, and perhaps 1 ft. 6 in. deep at the centre, which exists on the west side of the hole at the surface, marks the amount of the material that thus filled the upper part of the shaft.) And a little reflection shows that the line of junction of the pebble beds with the clay beds below, is the spot at which the incessant trickling of water down the neglected shaft could not fail to produce, sooner or later, subsidences precisely resembling those which have appeared; for the effect of the water concentrated towards the base of the pebble beds, would be to undermine them and wash the disintegrated sand and pebbles down the shaft, together with a considerable but smaller amount of the subjacent clay. In this way a hollow would gradually be formed, conical in form, from the base of the pebble beds upwards, while the mouth of the shaft below would acquire a broad funnel shape, from the denudation of the upper surface of the clay. The Thanet-sand and chalk part of the shaft would probably be little altered, and the chalk cavern below would allow of the percolation through it of any quantity of water, and be at the same time more than spacious enough to receive any quantities of sand, gravel, or clay, the removal of which would suffice to cause a subsidence at the surface such as we have endeavoured to examine.

Note.—As the Subsidence Committee are by no means unanimous with regard to the origin of these holes, it has been resolved that in their forthcoming Report the various opinions held shall all be represented.—T. V. H.

SCIENTIFIC TEACHING.

By W. H. STONE, M.B., F.R.C.P.,
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IT is doubtful whether the generality of well-educated men fully appreciate the great, the radical, and the almost revolutionary change which has in the past thirty or forty years come over the scope and spirit of English liberal education. Indeed it can hardly be termed a change; but might be more correctly designated as a substitution of one branch of human knowledge for another. For whereas in the first forty years of the present century, the dead languages, especially Latin and Greek, History, Logic, and Metaphysics, fairly held their own against the computative sciences of Mathematics, Mechanics, Physics, and Chemistry, and the systematic or classificatory subjects of Botany, Geology, and Zoology as topics of teaching and examination; they seem at the end of the second forty to have been all but superseded. No doubt in the main the revolution, great as it undoubtedly is, has proved salutary. Englishmen, with their characteristic tenacity of existing forms, had retained all but unchanged in their large public schools and in the older universities a form of intellectual culture which really originated in the Middle Ages, or at the latest with the restoration of learning. This is no mere figure of speech. The writer of the present remarks took his first childish lessons, after mastering the rudimentary arts of reading and writing, from *The Boke of Roger Ascham*, and received his first rewards for saying, parrot-like by rote, the ancient farragos now only known by their initial words,—'Propria quæ maribus,' 'Quæ genus,' and 'As in præsenti.' Of the present generation, not one in a thousand has ever even heard of these mediæval *aide-memoires*, or of the somewhat more useful Scholastic Scheme of Syllogisms, beginning with the cabalistic formula, 'Barbara Celarent.' Later on, he and his companions were expected weekly to manufacture, *nolentes volentes*, a certain quantity of poetry!—God save the mark!—in the Latin and Greek tongues. He can well remember his father's remonstrance on finding him working at 'that nasty chemistry, when you have not done your Latin verses.' Perhaps the most singular travestie of teaching was the inculcation of that laboriously useless heap of conflicting rules termed the 'Greek Accents.' It was well known to every scholar that they were non-existent in classical times; that they were probably prosodiacal; that they sprang up about the time when Greek was going out of use as a spoken language; and that, except in very few instances, they now served no purpose whatever. In spite of this, they were steadily and perseveringly thrust down the throats of schoolboys, insomuch that ignorance of the hideous pedantry of a mediæval grammarian might involve the pain and humiliation of corporal punishment.

That all, or most, of this has been swept away is ground for unmixed satisfaction. But it does not absolutely follow that what is being substituted for it is beyond comment or improvement. There may be errors and pedantries developing in the new as in the older system. Nor are they difficult to point out.

The teaching of science has tended to give an impulse to the computative, to the disadvantage of the judicial and appreciative functions of students' minds. Indeed the computative faculty, so highly developed at times in men not otherwise liberally educated, is not the widest in intellectual scope, nor the fittest preparation for some branches of life-work. Men in after-life are called upon to use their imaginative powers, to sift evidence, and to weigh symptoms, as well as to solve problems. They may adopt artistic or literary pursuits, they may choose the professions of Law or of Medicine. In all these, the attempt to reduce the subject-matter laid before them to the strict conditions of an equation or a ratio, so far from being a fruitful mental effort, may absolutely prove a hindrance. There is a common type of mind which fails to see a proof which is not of the character of demonstration, and which, in its absence, neglects to use the faculty of judgment and decision so necessary in the common affairs of business.

The computing school, and especially those who teach its Physical branches, very correctly and consistently insist upon the solving of problems as a test of thorough knowledge. Mr. Day, whose work appears to be mainly performed 'in the laboratory of King's College, under the direction of Professor Adams,' in an excellent collection of questions upon Electrical Measurement, says:—'It is now universally admitted that numerical *exercises are* necessary in the study of the experimental sciences, both as giving practice in the application of the various theories, and as affording tests of ability to comprehend as well as to apply that which has been learned.'

It must be remembered, however, that even among advanced and professed mathematicians, the faculty of solving problems is very unequally distributed; a fact which is openly recognized at the great mathematical University of Cambridge. The problems themselves are often open to comment, as partaking of the nature of enigmas, or riddles, rather than as fair tests of knowledge. Like riddles, moreover, they exercise a kind of fascination on their concoctors, and are very liable to figure in papers of questions. The writer, for instance, has seen in a paper on Physics a question which involved an indeterminate equation, and of which the solutions were infinite in number. Surely this should have been relegated to its kindred Algebra. But an instance which has occurred within the present year is so exceptional as to deserve quotation. It was a Pass, not an Honours paper, set for Matriculation,—the primary and initial step of the whole University career; a gate to further knowledge, which should be prudently left as wide open as is consistent with a reasonably high standard. The paper consisted in all of sixteen questions, and is therefore too long for quotation in full. Of these, says the heading,—

'*Not more than Eight Questions are to be answered, of which at least Two must be selected from Section A.*

A.

'1. State your reason for regarding a pound as a unit of mass and not of force. What is the most convenient unit of force when a foot, a pound, and a second are units of length, mass, and time, respectively?

'2. State the conditions necessary for the equilibrium of a body free to move in one plane. To what do these conditions reduce when one point in the body is fixed?

'3. A solid right circular cone of homogeneous iron is 64 inches in height, and its mass is 8192 lbs. The cone is cut by a plane perpendicular to the axis so that the mass of the small cone removed is 686 lbs. Find the height of the centre of gravity of the truncated portion remaining, above the base of the cone.

'4. A heavy body starting from rest slides down a smooth plane inclined 30° to the horizon. How many seconds will it occupy in sliding 240 feet down the plane, and what will be its velocity after traversing this distance? [$g = 32.$]

'5. What is the "Kinetic Energy" of a moving mechanical system? A shot of 1000 lbs. moving at 1600 feet per second strikes a fixed target. How far will the shot penetrate the target exerting upon it an average pressure equal to the weight of 12,000 tons?'

If it be borne in mind that judgment on the five momentous mathematical generalizations (for they are hardly within the pale of Physics proper) was demanded of boys averaging sixteen or seventeen years of age, fresh from school, it will be evident that the race of schoolmen and of De Morgan's 'Conundrum'-makers is not yet extinct, and that the current rumour of the award having been returned to the examiners for mitigation may have some foundation in truth.

It is interesting to note how this radical change in the scope and subjects of education has reacted on our older and on the more recently founded Universities. Far in the van stands that of Cambridge. Here, from the traditional character of the instruction given, little modification was required to bring modern requirements into harmony with the older teaching. Ever since the appointment of the great author of the *Principia*, the discoverer of the Binomial Theorem, and of the 'Fluxionary Calculus' to a Junior Fellowship in Trinity College, A.D. 1667, Physics and Mathematics have had their full and abundant share in the curriculum of this University. If, therefore, there has been a greater leaning towards Physics and Applied, as distinguished from Pure Mathematics, it has been accomplished, almost unperceived, under the guidance of men like Stokes, Thomson, Clerk Maxwell, and his successor, Lord Rayleigh; who combine the highest powers of numerical analysis with the imaginative, constructive, and inventive faculty of Wheatstone and Faraday.

At the sister University of Oxford the case is very different. Here the method of the schoolmen and the misrepresented teaching of Aristotle reigned supreme until our own time. The anachronism was indeed expressed in concrete form by a single word. The 'Science,' which up to 1852 formed one foot of the tripod, with Scholarship and History, on which Honours were adjudged, was the Science of a thousand years before, the Metaphysics and Moral Philosophy of the Stoics,—of those who, proposing to teach it, wrote over the entrance to their school, *οὔδεις ἀγεομετρήτος εἴσιτο*, which, in the terms we are now using may fairly be translated, 'Let none unacquainted with Physics enter.' It was a purely mental analysis of the great problems even then seen to underlie our simplest conceptions of the universe. The change required in this centre of learning was therefore from Metaphysics to Physics; it was a scientific putting of the cart before the horse; a substitution of Pythagoras *or Archimedes* for Plato or Aristotle, as the latter then and there was studied; namely, in his dogmatic treatises on Ethics, Politics, Rhetoric, and Metaphysics, and not in his far stronger genius as a natural historian and zoologist.

Is it to be wondered that the wrench thus suddenly given produced molecular change? that the impulse overran the neutral point? and that those who previously had been commended for accurate knowledge of the metaphysical attributes of God, should require time to learn the internal economy of a Holothurian, the exact chemical constitution of ethylic-diethyloxamate, or the formula for Carnot's reversible Heat-engine? Even now, within an ace of thirty years from this intellectual cataclysm, poor old Oxford is only just recovering from a protracted state of vertigo, and settling down again to useful work. It is sad that she should have to chronicle the early loss of one who has been a main agent in the revolution. The Linacre professor of Physiology, who began as an orthodox First-classman in the school of *Litteræ Humaniores* in 1850, dies in 1881 at the age of fifty-two an advanced exponent of modern views in Anthropology.

In the modern University of London, instituted forty years ago, we see another phase of the phenomenon which has been ably and convincingly commented upon by Dr. Bristowe, in a pamphlet confidentially communicated at first to Earl Granville, the Chancellor, but now *publici juris*. His object is mainly connected with the special study of Medicine, and the sustentation of the profession to which he and the present writer specially belong. But he makes incidentally so many shrewd and convincing comments on science-teaching and on its general tendencies, that they fully deserve reproduction. He commences by observing that for some reason or other the University of London has hitherto failed to take that position in relation to the medical profession which the founders of the University doubtless expected of it, and which it is important it should hold. He shows that in forty years only 761 candidates have graduated in medicine, or an annual average of nineteen, only representing a single man for each of the medical schools in England. He compares this poor result with those of the Universities of Paris, Vienna, Berlin, and Edinburgh, even with those of Glasgow, of Aberdeen, and of the Queen's University in Ireland. After commenting on several possible causes of this comparative failure, he continues:—

> 'But is it not possible that the examinations are too exacting, and so tend to starve the University and do injustice to the candidates? And is it certain either that the medical graduates owe their intellectual eminence to the ordeal to which they have been subjected, or that they have any such collective pre-eminence as justifies the plea for maintaining the present exclusiveness o [illegible] y?

'In reference to the former question, having first directed your Lordship's attention to the fact that only a small minority of the students entering the medical profession in England offer themselves as candidates at the Matriculation Examination, let me trace the subsequent history of this minority. Nearly fifty per cent of the total number fail at Matriculation; of those who, having matriculated, present themselves at the Preliminary Scientific, again nearly fifty per cent fail; of those who, having passed the Preliminary Scientific, present themselves at the first M.B. Examination, nearly thirty-five per cent fail; and of those who finally become candidates for the degree of M.B., nineteen per cent are rejected. The collective result is (allowing for the fact that no inconsiderable number of the candidates faint by the way, and never proceed beyond the Preliminary Scientific or First M.B. Examination) that not ten per cent of the young men who enter at the lowest of the series of examinations emerge successful from the last; and that at least seventy-two per cent of the whole number are rejected at the Matriculation and Preliminary Scientific Examinations—examinations in subjects which, with scarcely an exception, have no direct bearing on medicine. Surely the fact that the examinations required of aspirants for the M.B. Degree are so devised and so conducted, that they involve the rejection of nearly three-fourths of them before they have been afforded the slightest opportunity of displaying their acquaintance with any of those branches of knowledge which are the almost exclusive objects of their study in the Medical Schools, which alone it is essential that a medical man should know, and which ought to be the real basis of a Degree in medicine, is sufficient to condemn them as tests of fitness or unfitness for the medical membership of the University. As a matter of fact, those who have never presented themselves at the portals of the University, together with those who have lost heart by being rejected at its earlier examinations, include the great bulk of the more distinguished pupils at our hospitals; of whom many leave us before the completion of their pupilage to gain in Scotland, Ireland, or elsewhere, the Degrees practically denied them in London.

'But the chief cause is the difficulty of the preliminary examinations. This has always been excessive, but of late has been scandalous. The difficulty and indeed the uncertainty of the results are now so fully recognized, that many students who under other conditions would have become Candidates, feeling the importance of utilizing the time at their disposal to the best advantage, do not think it worth their while, or do not dare to face them. Again I appeal to statistics. In the twenty-three years ending with 1860, the rejections at the Matriculation Examination were under 16 per cent. In the next eighteen years, without any apparent cause, they rose to 49 per cent, or to more than thrice their former average; and during the last three years of this time, they actually exceeded 50 per cent. It was in the year 1861, from about which time the extraordinary increase in the rejections at Matriculation dates, that the Preliminary Scientific Examination was instituted, partly to relieve the first M.B. of some of its less strictly medical subjects, partly to insure a more exact knowledge of those subjects on the part of the student. A new obstacle was thus interposed in the medical [illegible]dent's career, an obstacle so serious that it has involved *from first to* last the rejection of 47 Candidates out of every 100.

It might at least have been supposed that the increasing stringency of the Matriculation Examination, and the further filtration of Candidates through the Preliminary Scientific, would have had the effect of insuring better results in the First and Second M.B. Examinations than had been previously attained. Not in the least. For whereas down to 1860 the rejections at the First M.B. were only 27 per cent, and those at the Second M.B. only 16; since 1860 the rejections at the First and Second M.B. have been respectively 35 and 19 per cent. Collecting these several results, it appears that whereas prior to 1861 the rejections at the *three examinations* which medical graduates had then to undergo, were severally 16, 27, and 16 per cent; from 1861 inclusive the rejections at the *four examinations* now in force have been severally 49, 47, 35, and 19 per cent; and that while in the former period the chances were that out of every 100 medical Candidates at the Matriculation Examination, 51 would become Bachelors of Medicine, in the latter period the chances of final success have dwindled down to 14 per cent.

'The fault of the regulations of the University in reference to the Matriculation and Preliminary Scientific Examinations, is that examination in too wide a range of subjects, and too extensive a knowledge of them, are required of Candidates who, for the most part, are fresh from school, or at any rate have had very little time for serious study after leaving school. The mere enumeration of the subjects required of a Candidate at the Matriculation Examination, is sufficient to condemn it as an entrance examination. They are as follows:- Latin; two out of the three languages, Greek, French, and German; English; English History with Modern Geography; Arithmetic; Algebra, up to and including simple equations; the first four books of Euclid; Natural Philosophy, including Mechanics, Hydrostatics, Hydraulics, and Pneumatics, Optics and Heat; and Chemistry. Why, even a public school-boy of high attainments could not pass such an examination in virtue only of the knowledge he has been acquiring for many years at school; and in the case of boys of average intelligence and education, it involves an outrageously severe and altogether unremunerative mental and physical strain. Who among the Senate even, or who among the examiners, is competent at this moment to pass successfully through such an ordeal? The Preliminary Scientific Examination, again, is one of exceeding difficulty, far too difficult, indeed, for that period of a student's career at which he is required to pass it. Moreover, as I have already observed, it embraces a list of subjects, scarcely one of which has any direct bearing on medicine. In fact, they are placed here in order to get rid of them at once and for ever, so that they may not embarrass the student's further progress. The subjects are:—Mechanical and Natural Philosophy, treated far too profoundly for most men who aim at a degree in medicine; Zoology, which can only be satisfactorily studied after the student has learnt anatomy and physiology; Botany, which is of very little, if any, use to a medical man; and Inorganic Chemistry. Is it astonishing that a large number of youths fail to pass the examination?

'The faults in the conduct of the examinations relate to the quality of the questions which are set, and to the standard of merit which the examiners adopt. As to the general quality of the questions, I have looked through paper after paper set at the Matriculation and Preliminary Scientific Examinations, and have been struck over and over again with the relative abstruseness of the questions, their inappropriateness or their unfitness as tests of a Candidate's actual knowledge. And I feel sure that most competent and unbiassed persons, who will take the same trouble that I have done, will acquiesce in the justice of my criticism. The question as to whether the examiners, generally, set up too high a standard of merit is one of great importance, yet one which I can scarcely venture to answer decisively. There are several considerations, however, which convince me that my opinion on the matter is in the main correct. They are, the gradually increasing ratio of rejections to passes; the general character of the questions proposed; and the fact, to which I can myself testify, that (apart from the personal qualities of the examiners) the traditions of the University favour excessive strictness of examination, and the maintenance of a very high standard of merit. I may remark in reference to this subject, that young and inexperienced examiners tend to be needlessly and unjustly severe; and that examiners in subjects of relatively little importance are apt to assert by undue strictness of examination the importance of their specialities.

'Finally, there are two other points in relation to the examinations which might, I think, be reconsidered with advantage both to the Candidates and to the University. *First*, I have never yet been able to understand why, when a Candidate rejected at any examination has taken a first class in one or more of the subjects of that examination, these successes should not be counted to his credit when he offers himself a second time for examination. It would be a great relief to the examiners, and not only a great relief but a simple matter of justice to the Candidates if such a practice were adopted. Of the extreme hardship, if not unfairness, of the present rule I can quote conspicuous examples. *Second*, I have also never yet been able to understand why the Senate should forbid absolutely that men who, at a comparatively late period of their studentship, or even at some subsequent period of life, desire to become graduates of the University, and who are able to adduce satisfactory evidence that they have complied strictly with all its essential requirements, should be allowed to present themselves for the successive examinations at the shortest possible intervals. Surely, under such circumstances, the only proof of fitness for its Degree the University can reasonably require is competence to pass its examinations. I have no wish for the University to relax its regulations so far as they affect the generality of students; but I am sure it would be well for it to reserve to itself the liberty of dispensing with some of its merely formal requirements in exceptional cases. The want of such a power, or the refusal to exercise it, has lost to the University many graduates who would have done it honour.

'It has not been under the guidance of such a spirit as this, that, with all their faults, the Universities of Oxford, Cambridge, and Dublin, and the great Continental Universities, have gained reputation and success: it is not thus that the University of Edinburgh has acquired and deserved its world-wide fame as a Medical University; nor is it thus that the University of London will ever attain that position in relation to its affiliated Medical Schools which the University of Edinburgh holds to the Medical Schools of Edinburgh.'

The great vigour and dispassionateness which characterize the criticisms of a leading scientific physician, himself a distinguished graduate and prizeman of the University of London, is abundant excuse for the free citation which the writer has indulged in. The argument here given is moreover substantiated by statistical evidence which is beyond comment. It is really a pressing question, for of all wild beasts which are liable to be let loose on an innocent and unsuspecting public, perhaps the most dangerous is the school-master *in excelsis*. Against him there is often no court of appeal, and no living man except the licensed keeper of lunatics is more liable to intellectual contagion. Every sensible man is cognizant of the pedantry and harshness which often characterizes the proceedings of the School-board Inspectors. It were well if public opinion, the only higher authority, looked more closely after the higher and now practically irresponsible leaders of our studious rising generation. *Quis custodiet ipsos custodes?* is a motto which applies not only to the blue-coated guardian of the public peace, but even more to the established regulators of our national education.

REVIEWS.

THE CAT.*

IT was a happy conception on the part of Professor Mivart to teach natural history on the basis of careful study of a single type in each class of animals. In this he follows out the precept and example of Prof. Huxley, but in a way that is entirely his own. The Cat appears to have been selected for study because, from the ease with which examples may be obtained, it is better suited for examination than any other animal, while many might anatomize the Cat who could have no opportunity of dissecting the human subject. In construction, the plan of the work is novel, in so far as the author presupposes no previous knowledge on the part of his reader, but provides him with the elementary physiology and anatomy necessary to appreciate the subjects discussed; so that in parts the book has a curious appearance of mixing knowledge at once elementary and abstruse, which may disappoint the naturalist who anticipates an exhaustive monograph on the Cat, but is helpful to all beginners. The work is well written, well illustrated, clearly arranged, and is certain to exercise a great influence on the future study of biology, because this is the first time in which so many modes of regarding an animal have been presented simultaneously, and on the whole with such freedom from technicalities. Remembering that it is a book for students, it must be pronounced well done.

The volume opens with a skilfully arranged introductory chapter, giving a zoological and historical account of the different domestic cats, and then passes on to define the several natural-history studies to which the Cat and its kindred may lead. Thus gently leading the reader, the author proceeds to consider the cat's form and skin, or, as he prefers to term it, the external skeleton. Here we begin to make acquaintance with the elementary tissues connected with the skin and skeleton, which are excellently illustrated by well-drawn woodcuts, some of them devoted to illustrations of the teeth of the cat and tooth structure. At the third chapter the skeleton is reached. The vertebræ are fully described and well figured; the skull is excellently drawn, and every bone figured in detail, showing internal and external aspects exactly as though the treatise concerned itself with the anatomy of man; though not being written exclusively for a learned class of readers, the style is somewhat less technical than is usual in anatomical works. The osteology of the limbs is similarly treated, sometimes with admirable drawings of the ligaments; but this part of the work might without doubt have been improved, had some further attention been given to indicating the attachments of the muscles to the bones. The fifth chapter describes the cat's muscles, leading up to a consideration of their arrangement by a few pages on muscle structure. Here there seems to be some deficiency of illustration; for though the student trained in the usual way would have no difficulty, further aids in dissection might be required by the reader for whom the book is designed. The chapter on the cat's alimentary system is followed by a discussion of the circulatory organs. Then succeed chapters on respiration and secretion. The ninth chapter deals with the nervous system and organs of sense, and this is in some respects the most carefully prepared chapter. The tenth chapter treats of the development of the cat, and of the subject of development generally. This is perhaps the weakest chapter, since there is comparatively little said which might not as well have occurred in a treatise on any other mammal.

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* *The Cat. An Introduction to the Study of Back-boned Animals, especially Mammals.* By St. George Mivart, Ph.D., F.R.S. With 200 illustrations. 8vo. London: John Murray. 1881.

The anatomy here ends. It is throughout plain, descriptive exposition; nothing whatever is said, such as might have been anticipated from the introductory chapter, of the comparative anatomy of the cat. There are no indications of the modifications which the skeleton assumes in other carnivora, and no indications of the distinctive elements which define the carnivorous skeleton of which the Cat is the type. This same want of grasp extends to the study of the muscles and all the other organs; yet the fact that the Cat is taken, as the title tells us, as 'an introduction to the study of back-boned animals, especially mammals,' would have led us to anticipate that, after studying the type, we should have been led up to a contemplation of the ways in which it is modified. This is a want of symmetry, and we cannot but think that such knowledge would have vastly augmented the student's interest in his work, and have paved the way for his contemplation of the higher problems of anatomy and physiology which must inevitably be forced upon his attention. It is in no way met by the chapter on the Cat's place in nature.

The author entitles the eleventh chapter the Psychology of the Cat; but here we find a great deal about psychological questions, and less than we could wish about the Cat. It is true, as the author remarks, that we cannot, without becoming cats, perfectly understand the cat mind, and this may account for the difficulty obviously experienced in expounding the subject. When he comes to the analysis of mental powers which the Cat is stated not to possess, there is sure to be difference of opinion among his readers, in proportion to their observation from nature and psychological training; for he denies to cats all the truly rational faculties, and would draw a sharp line between the mind of man and mind in brutes. The soul comes in for consideration, perhaps for the first time in a work of this character; but the author uses the term in a sense somewhat different from that usually accepted. With him it is 'that principle of individuation which makes the animal what it is, though it has no actual existence apart fro [illegible] ter it vivifies; yet it is the animal *par excellence*, the matter which it is composed being but the subordinate part of that compound but indissoluble unity—the living animal.' The twelfth chapter, entitled the Different Kinds of Cats, describes in brief zoological fashion, fifty species of the Cat kindred, with the aid of illustrations. Then succeeds some account of fossil cats, or Felidæ, in which are represented a number of new genera defined by Professor Cope. Here, again, we miss the analytical conclusion which ought to have followed, pointing out the relations of cats to each other, and the differences which distinguish the animals mentioned from each other. The thirteenth chapter is an article on the Cat's Place in Nature. This is really a statement of Prof. Mivart's views on classification; and after the lower animals have been disposed of, the Cat is ingeniously compared with the lower Vertebrates merely to exemplify their structure; and then the distinction of Carnivora from the other groups of mammals is given. Some detail is gone into concerning points in the base of the skull which distinguish bears, dogs, civets, paradoxures, hyænas, and other animals, and the distinction of the Felidæ from each of the allied families is formulated in a series of characters drawn partly from external structure and partly from anatomy.

The Cat is considered to be the typical genus of its family; the cheetah is a generalized normal form; the lion a specialized normal form; the Canidæ are said to be the most generalized aberrant form; bears depart from the normal standard of the order in their own way. But the author's views incline him to state that 'something may be said in favour of cats being the highest of mammals, the very flower and culmination of the mammalian tree.' This really looks like a sop in the pan for the Cat, after it has been anatomized.

The last chapter but one is the Cat's Hexicology, which is explained to be its environment, or relations to space, time, physical forces, and conditions of life. First it is observed that no cat dwells with the polar bear, and that for some species no region is too hot. Some species are diurnal; none are aquatic; and they drink but little water. An interesting but brief account is given of the geographical distribution of the Felidæ; but there could be no good reason for introducing an account of the recognized natural history regions of the earth with their characteristic animals. Then follows a short account of the palæontological history of cats. The oldest are found in India and Greece, in beds of older Pliocene or newer Miocene age; and the chapter concludes with some account of the various internal and external parasites with which cats are troubled. We are sure that most readers will be comforted to learn that Hexicology is a science; but how parasites, extinct allies of the tribe, geographical distribution, and the nfluence of phenomena of nature, can hang together in scientific relation, is not much clearer after Prof. Mivart's exposition than it was before.

The volume closes with an account of the pedigree and origin of the Cat. t is contended that the cats were derived from the Insectivora, which the author would take as the parent stock of all Mammalia, instead of deriving the higher forms from the Marsupials; and he argues that *Hyænodon* and other ertiary mammals supposed to have marsupial affinities, are just as likely to be related to the Insectivora. The views adopted would lead to the belief that the old mammals *of the* Stonesfield slate are also insectivorous, against which something might be said. An excellent tabular scheme gives the conclusions at which the author arrives as to the pedigree and affinities of the animals with which the cat is most closely related; and then, as was to be expected, the author passes on to consider the Cat's origin, or, in other words, the doctrine of evolution in those aspects in which it commends itself to Prof. Mivart; his contention now, as ever, being for an Individual Divine government of the universe, while the mass of scientific men are seeking to discover what the government really is, and how it operates for the well-being of the world.

The book is strongly tinged throughout with the author's individuality; and it is obviously the outcome of his best and most earnest labour for the advancement of sound learning.

MUSCLES AND NERVES.*

THIS is one of the volumes of the International Scientific Series, and was written by the learned and intelligent Professor in 1877. He dedicates the book to the illustrious Emil Du Bois-Raymond, his master, and writes, in the Preface, that 'this attempt at a connected account of the general physiology of muscles and nerves is, as far as I know, the first of its kind.' He makes the following extraordinary assertion:—'But anyone who endeavours to gain an idea of this branch of knowledge from the existing text-books of physiology will probably labour in vain.' Recalling, therefore, what we learned from Todd and Bownan, who had the advantage of witnessing the experiments of Mateucci, and who were perfectly acquainted with the work of Faraday on *Electrical and Galvanic Currents*, it is interesting to make out how much further Dr. Rosenthal, the careful recorder of the work of Ed. Weber, E. du Bois-Raymond, and H. Helmholtz, carries us.

The first chapter relates to molecular and protoplasmic motions and ciliary motions, and there is no advance in it; and in the second chapter there are the good old truths regarding muscles, their form and structure. But then a new subject is opened up, and the muscle begins to be treated as a lifeless thing, and the physics of elasticity are explained. Some very simple facts are proved over again by physical experiment—the principal use of physiological laboratories—and the conclusion come to is—'The muscle on contracting is capable of lifting a weight. The same weight, however, extends the muscle, and the co-operation of the two forces—the contractile tendency and the elastic extension—produces, as we shall find, the final operation on which labour depends.' There is nothing new in this, except the new 'force' of contractile tendency, which really means contraction pure and simple. The author deals with tetanus, and thinks that he is bringing us nearer the comprehension of that muscular condition by comparing it with the enduring contraction which is the result of the action of rapid alternate currents of electricity. Certainly the phenomena are analogous, but by no means identical. The author states that warmth and internal motion exist in the muscles during tetanus, but this is not new, for ruptured fibres have been seen under the microscope for the last forty years. Then we are told that the absolute force in the human muscle is equal to six to eight kilogrammes. We presume that the author means energy. But there is a struggle between common sense and physics in the calculation. Weber proved by experiment that the whole force (energy?) of the calf muscles of man, of both legs, 'is greater than the weight of the body.' How can a child raise itself on its toes and jump up in the air if this is not true?

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* *General Physiology of Muscles and Nerves.* By Dr. S. Rosenthal, Prof. of P[illegible] in the University of Erlangen. 8vo. London: C. Kegan P[illegible] 881.

The author states that it is easy to show that chemical processes occur within the muscles, but that our knowledge of the chemical constituents is very incomplete. He explains Helmholtz's experiments to prove that muscular contraction produces warmth,—rather a work of supererogation. The rigor mortis is put down to the coagulation of some liquid in the living muscle and to the formation of an acid. The book is full of illustrations cf different methods of demonstrating the relations of electricity and muscular action, and it is to be feared that if it is carefully studied people will not care much about having to take the useless trouble of explaining vital phenomena by those of pure physics.

THE BRAIN.*

THIS is a book which ought to be in every library, for it is full of good facts and solid physiology, and contains many interesting hypotheses. It treats first of the nervous systems of the Invertebrata, and considers the data concerning the human brain which are derived from the study of them; and then the brains of fishes, amphibia, reptilia, and birds, are considered in relation to reflex action, sensation, ideation, and perception. Instinct is considered nascent reason also. After dealing with the nervous centres of the higher Vertebrates, Dr. Bastian considers their mental capacities and the relation of brute and human intelligence. There is a capital chapter on 'Phrenology Old and New,' and the book ends with a discussion of the problems relating to the localization of higher cerebral functions. It is a well-written work, and worthy of the reputation of the author.

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* *The Brain as an Organ of Mind.* By H. Charlton Bastian, M.A., M.D., F.R.S. 184 Illustrations, pp. 708. The International Science Series, Vol. XXIX. 8vo. London: C. Kegan Paul & Co. 1880.

THE SPIRIT OF NATURE.*

MR. Baildon writes like an accomplished gentleman; he has plenty of ideas, a command of good English, and does not fear, even in these days of practical Philistines, to elaborate elegant and eloquent sentences. He has studied the writings of the advanced school of evolutionists, and decides that physical and physiological properties are absolutely independent of moral conditions. He states, 'Something of the history of organisms, of physical evolution, we are beginning to know, but spiritual evolution is still a mystery.' In these ideas he will be supported by many more evolutionists than he thinks. There is an interesting chapter in which the author deals with science and poetry, and he comes to the conclusion that science is no more antagonistic to poetry than it is to religion. He follows it up by a good attack on the doctrines of Automatism and on the conclusion-jumping of the advanced school. But earlier in the volume Mr. Baildon mistakes Charles Darwin's views, and in fact he states, 'I have read a great part of Mr. Darwin's *Origin of Species*.' He might have studied the whole over and over again, and with benefit, and if he had he would not have written the following nonsense:—'His followers have seen the weakness of his position, and have many of them gone over to atheism. Now I trust I shall not be misunderstood, but that you will bear with me till I have fully explained myself, when I say that science must always be in a sense atheistic. By atheistic here is meant not what denies Deity, but what leaves it out of account. Science, so far as it seeks only the particular finite, intelligible or secondary cause, and has no concern with the universal, infinite or first cause. When, for example, we say to a child that God made such and such a thing we give the child no scientific information whatsoever, though we impart a religious truth.'

Cruelty of Nature is the heading of one chapter, and is eminently polemical and of course personal. He calls the Laureate a Christian calumniator of nature, and opposes the idea that a charge of cruelty can be established against nature. But the conclusion he comes to is that nature is not guilty if the pain and misery of men and animals is of any use. It must be shown that the pain occasioned by her processes is unnecessary or unjust. He jumps at the conclusion that the necessity of pain has been established because of the existence of pleasure, and the use of pain is a warning. We cordially recommend the book to sober-minded readers of all shades of opinion, and believe that they will come to the conclusion that evolution and science are compatible with the belief in a Creator whom man may approach through his intellect.

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* *The Spirit of Nature, being a Series of Interpretive Essays on the History of Matter from the Atom to the Flower.* By H. B. Baildon, B.A. Cantab. 8vo. Pp. 216. London: J. & A. Churchill. 1880.

ANTHROPOLOGY.[*]

MR. E. B. TYLOR'S Manual of Anthropology does not profess to be an exhaustive treatise upon the subject, and indeed, as he himself says in his preface, some portions of the science of man are designedly handled in a somewhat superficial fashion. This statement relates more especially to the ethnographical section, in which the author has avoided detailed reference to the more technical treatment of the physical characters of the various races of mankind. The ordinary student, however, will find quite sufficient information in the first three chapters, which deal with what may be called the natural-history side of the subject, to satisfy his requirements; those who wish to study this branch more profoundly will easily find no lack of other guides.

The remaining chapters are devoted to an exposition of the principles of the science of Anthropology. Taking, as his starting-point the notion of the primitive barbarism of our earliest ancestors, Mr. Tylor shows in a very clear and interesting manner the mode in which the different characteristics of man as a social creature have originated and attained to their varying degrees of development; and by wide, but judicious generalizations, and a most careful treatment of the matters in hand, he has certainly succeeded in producing a picture of the course by which mankind have attained to their present state which leaves little to be desired.

After dealing, as already stated, with the general natural-history facts of Anthropology, Mr. Tylor passes in review the development of the special characteristics of man, naturally commencing with language, as being the distinction between man and the lower animals upon which the progress of the human race in all other respects mainly depends. The art of writing of course constitutes a sort of appendage to language. The four following chapters relating to the arts of life and dealing with the invention and improvement of weapons and instruments of all kinds, leading up to the most complete machinery at present in use; the progress of mankind in the matters of dwellings, clothing, and navigation; the use of fire and cookery, which used to be cited as the one recognizable distinction of man; the manufacture of vessels of various kinds, and the employment of metals in the arts and as money, will be read with the greatest interest, as they contain an infinity of curious information brought together from the most various sources, and open up many new views of the connexion between old and frequently obsolete practices, and those of the most advanced civilization.

One chapter is devoted to the arts of pleasure, under which head Mr. Tylor includes, among other things, poetry and music, dancing, the drama, the imitative arts of sculpture and painting, and games. The remaining chapters deal with the origin and progress of scientific knowledge, of spiritual ideas and religion, of history and mythology, and of society.

As we have already stated, the book is most interesting and suggestive, and so far as we are able to judge, the materials have been selected with great judgment, and most carefully placed in the clearest point of view. Here and there, indeed, we detect small errors,—for instance, in speaking of costume the author seems to misinterpret the significance of the two useless buttons on the backs of our modern coats; and in another place he represents the French future tense of verbs as formed by adding the present tense of the verb *avoir* to the infinitive of the verb, so that *je donnerai* would signify, 'I have to give'! an absurdity which we are sorry to find in so good a book. The illustrations are good and tolerably numerous, especially in the natural-history chapters.

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[*] *Anthropology: an Introduction to the Study of Man and Civi*
By Edmund B. Tylor. 8vo. London: Macmillan and Co. 1881

MONTICULIPORA.*

A YEAR and a half ago we had occasion to notice an important work on the so-called Tabulate Corals, then lately published by Prof. H. Alleyne Nicholson. In this book Prof. Nicholson referred, in immediate connexion with the Chætetidæ, to a group of organisms forming the genus *Monticulipora* and some allied genera or sub-genera, and he has now produced an equally elaborate treatise, which is devoted exclusively to those curious and problematical fossils.

The genus *Monticulipora* was founded by D'Orbigny in 1850, for the reception of certain Palæozoic corals, which he defined as having the cells close together, poriform, at the surface of a branched or incrusting whole covered with small conical projections; and it was from the presence of these little elevations or 'monticules' that the name of the genus was derived. Other forms showing more or less agreement with the characters laid down by D'Orbigny were soon found in various parts of the world, or previously described species were referred to the new genus, whilst in some cases new genera were formed for the reception of new forms; but the whole were still always considered to belong to the Corals, and in fact to the section Tabulata, after the establishment of that group by Milne Edwards and Haime.

Of late years, as all palæontologists know, the rights of the group of Tabulate corals to exist as a systematic entity has been frequently called in question, and we may hold that the *coup-de-grace* was given to it by Prof. Nicholson in the work already referred to; but, as will indeed be seen even from our imperfect notice of that book, the business of negation was easier than tha of affirmation, and while it might without much difficulty be demonstrated that the fossil organisms in question do not form a systematic whole, it was by no means an easy task in all cases to decide where the dismembered parts should be placed.

In his former book, Prof. Nicholson was inclined to regard *Chætetes* and *Monticulipora* as Alcyonarian forms, notwithstanding the arguments put forward by Prof. Lindström and others in favour of their being placed with the Bryozoa (or Polyzoa). This question is discussed by him at considerable length in his new treatise, and he still holds, in opposition to the views of Prof. Lindström and Busk, and of Mr. Waters, that there is no unmistakable evidence of the Bryozoan nature of the Monticuliporidæ. With regard to their relationship to the genus *Heteropora* especially, upon which much stress has been laid, he says, 'It is clear that the points of likeness between the two are by no means so weighty as the points of difference. On the one hand, we have a strong natural resemblance, a general similarity in the mode of construction of the skeleton and an agreement in the fact that in both genera the colony consists of two sets of tubes, crossed by transverse partitions. Such transverse partitions of the tubes (or, as we may loosely call them, "tabulæ") occur, however, in organisms of such exceedingly diverse affinities, that we can, admittedly, attach no value to the last-mentioned of the above resemblances. . . . On the other hand, to set against the mostly superficial points of resemblance above noted, we have a number of fundamental structural differences. Thus, in *Monticulipora* the walls of the tubes are imperforate; there are no traces of radiating spines or "septa," and in the dimorphic or trimorphic species there are usually important differences as regards the different groups of corallites. In *Heteropora*, on the contrary, the walls of the tubes are traversed by a very remarkable and exceptionally developed canal system; the tubes possess in their outer portions a well-developed series of radiating spines . . . and the interstitial tubes are in no way structurally different from the proper zoœcia.' From these and other considerations, the author declares, without denying the possibility that *Monticulipora* may belong to the Bryozoa, that his specimens lean decidedly towards the Cœlenterata 'as a proper resting-place for the genus.'

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* *On the Structure and Affinities of the genus Monticulipora and its Sub-genera; with Critical Descriptions of Illustrative Species.* 8vo. Black-[illegible] Sons, Edinburgh and London, 1881.

In the systematic and descriptive part of his present work, Prof. Nicholson makes no attempt at a monograph of the curious and puzzling group of fossils to which he has devoted so much attention, but simply endeavours to define clearly and accurately the species with which he is acquainted, and the generic and sub-generic groups to which they are best referred. His family Monticuliporidæ is made to include only the single genus from which it takes its name; and the other named groups of allied organisms, some of which were distinguished even before D'Orbigny established his genus, are treated provisionally as sub-genera. Of these there are *Fistulipora*, M'Coy, with which *Callopora*, Hall, is synonymous; *Constellaria*, Dana, including *Stellipora*, Hall, and *Dekayia*, M. Edw. and H.; and these three groups are regarded by the author as so far differing from the rest that their distinction may be considered of more weight, and they thus acquire a sort of quasi-generic value, in opposition to *Monticulipora* proper, which in its turn includes the subordinate groups, *Diplotrypa*, *Heterotrypa*, *Monotrypa*, *Prasopora*, and *Peronopora*—the last-named here proposed for the first time.

It would be manifestly out of place here to enter upon a criticism of the course adopted by Prof. Nicholson, if, indeed, anything of the kind could be profitably undertaken without a long study of the very objects investigated by him. The reader will easily see, from what is stated above, that the subject is an exceedingly difficult one, and that the attem-

classification leads to a sufficiently complex result—evidently, as the author justly says, the time has not yet come for a final monograph of the group. But in his characters of the genera, or sub-genera, and his long and detailed descriptions of the structure of numerous so-called species belonging to the sub-genera of *Monticulipora* proper, Prof. Nicholson has certainly done important work towards the perfect elucidation of these most difficult fossil organisms, and the abundance of admirable figures that he has given, both on half-a-dozen plates and as woodcuts scattered through the text, add immensely to the value of his work. His opinions as to the nature of the organisms are still *sub judice*, but whether they are right or wrong, his contribution to the history of the Monticuliporidæ will certainly prove a great help to future investigators.

SYSTEMATIC MINERALOGY.*

IN describing the various crystalline forms, the author of this volume deals only with their symmetry and general geometrical proportion, without entering into the question of the practical calculation and determination of individual examples. In doing this, the methods followed are mainly those of Groth's treatise on 'Physical Crystallography,' excepting that the plan there adopted of considering the physical structure of crystals before their geometrical properties has been abandoned in favour of the more common one of giving precedence to the latter.

The optical properties of crystals are considered at somewhat greater length than is usual in rudimentary books, and the phenomena of polarization receive special notice. A mixed system of crystallographic notation has been adopted. In the text, the forms are designated by their symbols according to Naumann, while the notation of their forces is by indices on Miller's system. It is explained that this has been done with a view of familiarizing the students with both systems, since, although the notation of Miller is probably the best, that of Naumann is more generally employed both in text-books and in original memoirs. The classification followed in the chemical portion of the volume is that of the second edition of Rammelsberg's *Handbuch der Mineral-Chemie*.

This book is not only a safe and useful guide to students desirous of acquiring a general knowledge of mineralogy, but will also serve as an excellent introduction to the large text-books of Dana, Miller, Descloizeaux, and Schrauf.

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* *Text-book of Systematic Mineralogy.* By Hilary Bauerman, F.G.S., Associate of the Royal School of Mines. London: Longmans, Green, & Co. 1881.

SIGHT.*

THE function of sight has engaged so much study, that one marvels that no one should till now have undertaken to explain its chief phenomena to the reading public. The physiological aspects of the eye have been fully discussed in Michael Foster's *Physiology*, for instance, and the physical considerations are sufficiently explained in most treatises on Optics; but Prof. Le Conte, in a volume of the International Scientific series, presents us with a larger view of this subject than comes under the consideration of a specialist. The author is a master of the art of professional exposition, singularly clear, full of information, and often original in his own views as well as in stating those of others: and, therefore, his work fills a gap in literature in an able way. The volume is divided into three parts, which concern monocular vision, binocular vision, and disputed points in binocular vision. After a short introduction, which explains the relations of the senses to the phenomena with which they are concerned, the first part gives an admirable account of the elementary physiology of the eye, in four chapters which concern its general structure, the formation by it of images, its properties as an optical instrument when compared with the work of the optician, some of its defects, such as old-sightedness and near and long sight, and the structure and functions of the retina. The second part of the work contains much that is novel, for few persons consider the relation of their eyes to each other. It is shown that everyone sees double, and that most persons are right-eyed, just as they are right-handed, because they are, as the author phrases it, left-brained. And an explanation is given of the reason why objects beyond or nearer than the point of sight are always seen double. The superposition of images, binocular perspective, and judgment of distance, size, and form, are the other subjects of this part. The perception of double images is a distinctive view, and leads the author to certain differences from the theories of Wheatstone and Brücke. The third part deals first with the laws of the motions of the eyes, which are considered to be parallel or convergent motions. A chapter is devoted to the horopter. It is obvious, that as each eye forms its image, and as the images are brought together and superimposed at the point of sight, the sum of the points which appear single, while the point of sight is unaltered, or horopter, may be a line or a plane. The author considers it to be a line. This and many other original views, well set forth, will ensure careful consideration for the physiological studies of one who has already enriched geological science with many new facts and important theoretical views.

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* *Sight: an Exposition of the Principles of Monocular and Binocular Vision.* By Joseph Le Conte, LL.D., Prof. of Geology and Natural History in the University of California. With Numerous Illustrations. 8vo. London: C. Kegan Paul & Co. 1881.

A GEOLOGIST'S NOTE-BOOK.*

MR. John Edward Lee, a well-known geologist and archæologist, and the translator of Keller's admirable work on *Lake-dwellings*, has published the contents of his note-books on geological subjects under the title of *Note-book of an Amateur Geologist*. As he commenced the study of geology under the auspices of Prof. Phillips at a very early period of the latter's career, it will be easily understood that the notes that he has accumulated, and here offers to the public in an unvarnished state, extend over a very considerable number of years; and as Mr. Lee has been in the habit of travelling over the continent of Europe as well as in his own country, his observations refer to an exceedingly wide range of surface. The earliest notes of all relate to the Isle of Wight, and date from 1829, in which year the author also visited France, as appears from notes and sketches of geological phenomena both at Boulogne and in the neighbourhood of Paris. His residence at Hull at this time, which no doubt brought him into contact with John Phillips, next led to his devoting some attention to parts of Lincolnshire and Yorkshire, and in 1840 we find him making a trip to the Baltic. Subsequently the mountain-limestone district of Yorkshire, the Western Islands and the Giant's Causeway, the Eifel and other parts of Germany, Switzerland, and Italy, were visited by him, whilst others of the notes attest geological activity in many parts of the United Kingdom.

Wherever he went, however, Mr. Lee seems to have kept his eyes open, and to have noted both with pen and pencil whatever struck him as remarkable in the geology of the localities he visited. As might be expected also from the disciple and intimate friend of John Phillips, his geological tastes by no means flowed into a single channel, and we find him taking the same interest in bits of stratigraphical geology, examples of contortion and upheaval of strata, glacial phenomena, traps, basalts, and other igneous rocks, intrusive and otherwise, matters of surface geology and even palæontology, so that the guest at his table has a tolerably various repast spread before him. As a man of taste as well as a geologist, Mr. Lee seems to have paid particular attention to cases in which geological structure of one kind or another has a marked influence upon scenery, and many of his best sketches have for their object the illustration of such points.

Mr. Lee has with justice interpreted his *Note-book* a little widely, that is to say, he has included in it reprints of a few papers, chiefly on palæontological subjects, that he has from time to time published. In this way we get papers on the Sponges of the Yorkshire Chalk, on Saurian Remains from the Wealden, on the Microscopic Structure of the Scales of *Lepidotus*, on the Geology of Nettleton Hill in Lincolnshire, on *Cupressocimus*, &c. The book is thus a summing-up of the results of its author's studies in geology during a long life, and naturally its contents are of a sufficiently miscellaneous nature. The drawings and sketches make 200 plates, and the notes, which upy ninety pages, consist, for the most part, of very brief explanations of

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Note-book of an Amateur Geologist. By John Edward Lee, F.G.S., 1. 8vo. London: Longmans. 1881.

the subjects of the illustrations, many of which, being facsimiles of the pencil memoranda made on the spot in the *Note-book*, are, as a matter of course, rough enough. Sketchy as the work is, however, the geologist will find many interesting details in it, and we think it is a pity that Mr. Lee, instead of arranging his materials in the order of date, did not adopt some sort of rough classification, such as would have served to guide those consulting his Notes more directly to the matters of which they may be in search.

TIN.*

TIN is one of those metals in which an Englishman may naturally take great interest. For many years it was supposed that the tin which furnished ancient nations with the means of making bronze was exclusively derived from the south-western corner of Britain; and although this source of national vanity has been long dried up, there is no doubt that a very large proportion of the tin used in the world until quite recently was obtained from the Cornish mines. Nowadays, indeed, the development of tin-mining in other countries, and especially in the far east, where labour is cheap and the stanniferous deposits are still comparatively untouched, has thrown the old Cornish industry into the background, and it will probably be many years before the British stannaries can attain anything like their former prosperity.

Nevertheless the production of tin, although it may be regarded as one of the minor metallurgical industries when compared with that of iron, copper, or lead, is of great importance, as the metal is applied to many purposes in which it would be hard to find a substitute for it. Those who take an interest in mining matters will therefore owe a debt of gratitude to Dr. E. Reyer, a distinguished Austrian geologist, who has devoted a great amount of labour to the investigation of the occurrence and working of tin ores in various parts of the world, and now publishes the results of his researches in a small octavo volume.

As will be seen from the title of his book, he views his subject from all sides, except that of the actual smelting, although some particulars of the results of this operation are also given. He commences with some Bohemian and German localities,—Zinnwald, Altenburg, Graupen (where tin was mined as early as the year 1200), and Schlackenwald, then deals with Cornwall and some very limited occurrences of tin in the Iberian peninsula, France, Italy, and Finland, and finally describes the stanniferous regions of Malacca, Banka, and Bilitong, and the most recently discovered tin-grounds of Australia and Tasmania. The metal is treated in connexion with these districts under the various aspects of its geological distribution, the mining of the ore, and the history of its production in each locality, the whole forming a compendious treatise which has every appearance of being thoroughly trustworthy.

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* *Zinn, eine geologisch-montanistisch-historische Monografie.* Von E. Reyer. *8vo. Berlin:* G. Reimer. 1881.

We may remark, however, that the author adopts that abominable so-called phonetic system of spelling, which, thanks to the good sense of the Government authorities, did not succeed in establishing itself as the state rule of orthography in Germany. It is melancholy to see men of cultivation giving in to a system of spelling which destroys the affiliation of the words in their language, and this, especially in the case of German, with no advantage that can be considered in any way to make up for the loss. Thus, in Italian and Danish, we are accustomed to see *f* used in place of *ph*, but this is no innovation, and why people who are accustomed to the use of the *ph* should discontinue it is rather hard to see. In the present book we find our old friends the Phœnicians transmogrified into 'Fönizier,' a word at which we really have to look twice before understanding what it means. But the letter to which these German phoneticists seem to be most inimical is the letter *h*, not from any cockney-like objection to aspirating it, but because it occurs in many words where it has not the effect of an aspirate. One would think that Germany had found itself to be like the country described by Hood in one of his children's tales, 'a land of Toomeniaitches.' Thus *th* is everywhere converted into *t*, and we get such elegant words as *Teil* and *Tat*, and from the latter we get *Täter*, which has a homely sound; and further, the *h* following a vowel is dropped, so that instead of *Jahr*, *mehr*, *sehr*, *ohne*, *wohl*, and *zahlen*, we get *Jar*, *mer*, *ser*, *one*, *wol*, and *zalen*. With regard to these last words we can only say that the German who would make no difference in pronouncing them when spelt in these different ways, has a very imperfect idea of the pronunciation of his own language; and if there ought to be a difference, what becomes of the phonetic spelling?

SCIENTIFIC SUMMARY.

CHEMISTRY.

Synthesis of Ammonia.—Mr. G. S. Johnson, having observed the formation of traces of ammonia while passing nitrogen gas over freshly hydrogenized copper at a red heat, was induced to make further experiments. He passed a mixture of hydrogen and pure nitrogen over spongy platinum at a low red heat. The hydrogen was produced first and passed through silver nitrate and sulphuric acid, over pumice moistened with sulphuric acid, hrough Nessler's reagent, and finally over the spongy platinum. The platinum having been heated to redness in the hydrogen and the absence of ammonia proved, nitrogen was evolved from ammonium nitrite and passed hrough the apparatus with the hydrogen. When the mixed gases reached the hot platinum, ammonia was formed, characterized by its odour, by its rendering the Nessler reagent brown, and red litmus blue, and producing white fumes with hydrochloric acid. 5·9 milligrammes of NH_3 were produced per hour in his way. Objections having been raised to this process, on the ground that he vapour of some ammoniacal salt might be carried through the apparatus by the rapid stream of gas, Mr. Johnson made further experiments. Hydrogen was passed through the apparatus and over the spongy platinum, heating the latter until it gave off no ammonia; the platinum was then allowed o cool, and a current of nitrogen was passed through to displace the hydrogen, with the intention of heating the platinum afterwards in pure nitrogen, so hat the ammonia salt, if present, might be dissociated and yield its ammonia. On the admission of the nitrogen to the cold platinum, however, ammonia was produced to the amount of 24 milligrammes in an hour. To avoid all chance of error, the author repeated the experiments with nitrogen obtained rom atmospheric air, but without success; nor was any ammonia produced when the nitrogen evolved from nitrite of ammonium was passed over heated copper before being brought in contact with the platinum. Hence t was to be inferred, either that the contact with the copper produced an inactive condition of the nitrogen, or that some nitrogen oxide present n the nitrogen was removed by the hot copper. The nitrogen produced rom ammonium nitrite was found to contain some nitric oxide, to emove which it was passed through ferrous sulphate, and then, to test its purity, through a tared tube containing freshly reduced copper heated to redness. When the gas has passed over a sufficient length of the ferrous sulphate, the tube acquired no increase of weight. This nitrogen, entirely freed from oxide, was now passed over cold spongy platinum, mixed with hydrogen, and 3 milligrammes of ammonia were produced in an hour. But when the mixed gases were passed over heated asbestos before reaching the platinum, no ammonia was produced until the asbestos-tube had cooled considerably. Hence the author concludes that nitrogen, like phosphorus, may exist in two states, active and inactive, the latter produced by exposure to heat. (*Journ. Chem. Soc.*, March 1881, pp. 128 and 130.)

GEOLOGY AND PALÆONTOLOGY.

Classification of Dinosaurs.—Prof. Marsh describes the characters presented, by a nearly complete skeleton of the gigantic Dinosaur, named by him *Brontosaurus excelsus,* and indicates a second species of the same genus (*B. amplus*) of about the same size, and several other forms of the same order from Jurassic deposits in the United States. He remarks that the collection of American Jurassic Dinosaurs in the Museum of Yale College, includes the remains of several hundred individuals, many of them in excellent preservation. The series is so complete, that he thinks it may serve as a basis for a provisional classification of the American Jurassic forms, which may be hereafter extended to include the Dinosaurs from other formations in America, and those of other countries. Of this proposed classification he gives the following outline:—

Order DINOSAURIA. Owen.

1. Sub-order SAUROPODA (Lizard foot). Herbivorous.
    Feet plantigrade, ungulate; five digits in all feet.
    Pubes united in front by cartilage; no post-pubis.
    Precaudal vertebræ hollow; limb bones solid.
    Family *Atlantosauridæ.*
    Genera *Atlantosaurus, Apatosaurus, Brontosaurus, Diplodocus,* and *Morosaurus.*
2. Sub-order STEGOSAURIA (Plated Lizard). Herbivorous.
    Feet plantigrade, ungulate; five digits in all feet.
    Pubes free in front; post-pubis present.
    Vertebræ and limb bones solid.
    Family *Stegosauridæ.*
    Genera *Stegosaurus.*
3. Sub-order ORNITHOPODA (Bird foot). Herbivorous.
    Feet digitigrade; four functional digits in the fore, and three in the hind foot.
    Pubes free in front; post-pubis present.
    Vertebræ solid; limb bones hollow.
    Family *Camptonotidæ.*
    Genera *Camptonotus, Diracodon, Laosaurus,* and *Nannosaurus.*

4. Sub-order THEROPODA (Beast foot). Carnivorous.
    Feet digitigrade; digits with prehensile claws.
    Pubes coossified in front; post-pubis present.
    Vertebræ more or less cavernous; limb bones hollow.
    Family *Allosauridæ.*
    Genera *Allosaurus, Creosaurus,* and *Labiosaurus.*
5. Sub-order HALLOPODA (Leaping foot). Carnivorous?
    Feet digitigrade, unguiculate; three digits in hind foot.
    Metatarsals much elongated; calcaneum much produced backward.
    Two vertebræ in sacrum; limb bones hollow.
    Family *Hallopodidæ.*
    Genus *Hallopus.*
6? Sub-order CŒLURIA (Hollow tail). Carnivorous?
    Family *Cœluridæ.*
    Genus *Cœlurus.*

Two of the above genera (*Diracodon* and *Hallopus*) are described as new in the paper from which this classification is taken.—*Silliman's American Journal*, May, 1881.

Silurian Plant Remains.—Traces of these fossils were first observed in 1875 by Dr. Hicks in some shale, interstratified with rather massive beds of grit, in Pen-y-glog slate quarry, about two miles east of Corwen. Further research has resulted in the discovery of more satisfactory specimens, and in showing that they occur at still lower horizons. The fragments are exceedingly abundant, in some places being so closely matted together as to form a carbonaceous seam over an inch in thickness. Some of the specimens are from half an inch to an inch in diameter, and of various lengths, but always in a broken condition, indicating that they did not grow in the position in which they are now found, but must have drifted here on being washed down by river floods. Thin seams of a very pure anthracite, showing occasionally indications of plant structure, occur also in the slates underlying these beds; and anthracite is frequently found composing the nucleus in some large nodules which are found at several horizons in the slates. Among the specimens found are some spherical bodies, resembling the *Pachytheca* of Sir J. D. Hooker, from the lower bed of the Ludlow series, supposed to be Lycopodiaceous spore-cases; also numerous minute bodies stated by Mr. Carruthers to be united in threes, and to agree with the forms of the microspores of Lycopodiaceæ, both recent and fossil; and some fragments, which may belong to these plants, and others, probably belonging to plants described by Dr. Dawson from the Devonian of Canada under the name of *Psilophyton.* The above testify to the existence of a very rich land-flora at the time. Mixed up with these, however, are numerous carbonaceous fragments of a plant described also by Dr. Dawson from the Devonian of Canada, which he referred to the Coniferæ, but which is, according to Mr. Carruthers, an anomalous form of Alga. The former called it *Prototaxites;* the latter renamed it *Nematophycus.* Numerous microscopical sections, showing the beautiful structure of this interesting plant from the specimens found at Pen-y-glog, have been examined by Mr. Etheridge and Mr. Newton, and their conclusions agree in the main with those of Mr. Carruthers. Mr. Etheridge, however, recognizes here a w species, which he calls *Nematophyrus Hicksii.* The resemblance generally between this very early (probably oldest known) flora, and the far more recent Devonian, is very marked, and indicates a tolerable uniformity in the character of the conditions, at those widely separated periods. The stratigraphical position of these plant-bearing beds may be stated to be about the horizon of the Llandovery rocks. They are shown in the Survey sections to rest immediately upon the Bala series, and some of the beds are even included in that group. The animal remains found in the same beds are all of marine forms, and the species would seem to indicate a gradual passage from Lower to Upper Silurian. The evidence seems to show that at this mid-Silurian period the immediate area where the plants are now discovered must have been under water, and that the mixture of marine and dry-land plants took place in consequence of floods or rapid marine denudation. The author indicated that the land-areas must have been to the south and west, chiefly islands, surrounded by a moderately deep sea, in which Graptolites occurred in abundance. (*Geol. Soc. Proc.*)

The Jurassic Rocks of England and France.—On the 27th April last the Rev. J. F. Blake communicated a most important paper to the Geological Society, in which he attempted to settle the many questions of correlation arising out of the detailed descriptions given of the various localities in the Paris basin where Upper Jurassic rocks are developed, by a consecutive survey of them all, undertaken by the aid of a grant from the 'Government Fund for Scientific Research.' In previous papers the names used for the great subdivisions and their boundaries were adopted without material modifications; in the present such modifications were proposed as may bring the English and Continental arrangements into harmony.

Five distinct areas were considered in this paper: 1. The Southern range; 2. The Charentes; 3. Normandy; 4. The Pays de Bray; 5. The Boulonnais.

1. *The Southern Range.*—This is continuous from the Ardennes through the Meuse, Yonne, &c., to the Cher. In the Ardennes the 'Ferruginous Oolite' corresponds to our Osmington Oolite, and to the Lower Limestones and Passage-beds of Yorkshire, the underlying 'Middle Oxfordian' being equivalent to our Lower Calcareous Grit. Above comes immediately the Coral Rag with *Cidaris florigemma;* and the stratigraphical and palæontological break is constantly between the Coral Rag and Ferruginous Oolite when that occurs. The Corallian is a well-marked formation, though its character is variability. It is divisible generally into two groups—Coral Rag and Supracoralline beds, the latter usually being the '*Diceras*-beds;' but in the Yonne there is a great development of '*Diceras*-beds below, associated with *Cidaris florigemma*, and massive corals, which are gradually introduced in going west. This part of the series in the Haute Marne has been described as very different; but the author did not at all agree with M. Tombeck's stratigraphical determination, and considers the 'Oolite de la Nothe' no more than the continuation of the Supracoralline *Diceras*-beds, which he considers to uniformly *overlie* and never to underlie the *Am. marantanus* marls, which latter are Oxfordian. In fact nothing abnormal occurs in this Department. The whole series has a tendency to degenerate into barren lithographic limestones, in which distinctions are lost. The Astartian and Virgulian beds were

traced through this range, the latter seldom showing any well-marked Pterocerian division, and the former being most connected with the overlying series. Above these are limestones hitherto called 'Portlandian,' in which two zones are constant; but above all are vacuolar Oolites, which alone may be truly correlated with the Portland rocks of England. The whole of the beds in this range are eminently calcareous, a true clay being scarcely anywhere seen.

2. *The Charentes.*—In these two Departments the lower portion is very calcareous, and the distinction of one part from another very slight; but the highest portion, both near Cognac and on the Ile d'Oleron, yields beds which may be paralleled with our true English Portland rocks.

3. *Normandy.*—The complete sequence has here been made out, from the true Oxford Clay of Dives to the Virgulian of Havre, and the similarity of the whole to the sequence in Dorsetshire is very remarkable. 'The Trouville Oolite' is the exact representative of the 'Osmington Oolite' with the Nothe Grits below; but the place of the Sandsfoot clay is taken by the true Coral Rag, whose right position in the Weymouth section is hereby determined. The Supracoralline beds are the sands of Glos, and the Astartian beds are the *Trigonia*-beds of Havre, which are the exact representatives of the 'Kimmeridge passage-beds.'

4. *The Pays de Bray.*—Nothing below the Virgulian is here seen, and the commencement of the so-called 'Portland beds' was considered by the author to be at a lower level than it is placed by M. de Lapparent, on account of the similarity to beds at Boulogne. The true Portland rocks occur as ferruginous sandstones with *Trigonia gibbosa.*

5. *Boulonnais.*—The Houllefort limestone was correlated with the Osmington Oolite. The Coral Rag of Brucdale was considered equivalent to that of the Mont des Boucards, the so-called limestones of the latter place being Supracoralline. The Nerinean Oolite and the Grès de Wirvigne represent the Astartian. The higher parts of the series have been already correlated.

From this study it was proposed—that the 'Lower Calcareous Grit,' and almost all the Coralline Oolite, should be placed in the Oxfordian series as the upper division, under the name 'Oxford Grit' and 'Oxford Oolite;' that the Corallian consists of two parts, the Coral Rag and the Supracoralline beds; that the Kimmeridgian should include the Astartian and Virgulian, the Pterocerian being a subzone; that the 'Upper Kimmeridge' and the Hartwell clay, with the 'Portland sand,' should make a new subdivision to be called Bolonian (the northern and southern types being both represented at Boulogne), which may be divided into Upper and Lower; that the true Portland limestone and the Purbeck be united into one group, as Lower and Upper Portlandian; the fact of the latter being freshwater being paralleled by parts of the true Portland having that character.

Changes of Level in Lancashire.—In a paper on the date of the last change of level in Lancashire, read before the Geological Society on the 6th April by Mr. T. Mellard Reade, the author described some observations made by him at Blundellsands, on the coast of Lancashire, near Liverpool, according to which, judging from the position of high-water mark, the land had gained considerably upon the sea between 1866 and 1874. At one end of a length of 350 yards, spring-tide high-water mark had receded 15 yards, and at the other end 5 yards. The author estimated that the deposit of sand that had accumulated in eight years amounted to an average of 10 yards wide and 2 yards deep. Allowing a further depth of one yard for sand that may have been blown over the top, he finds 10,500 cubic yards as the quantity of sand deposited in eight years on a shore-frontage of 350 yards, or 3·75 cubic yards per yard of frontage per annum. Applying this unit of measurement to the 16 miles of coast forming the western boundary of the deposit, he gets 105,600 cubic yards as the quantity of sand annually moved; 22 square miles of sand, 12 feet thick, give 272,588,800 cubic yards of sand accumulated, which, divided by the annual quantity, will give 2580 years as the age of the whole deposit of blown sand. The author adduced other evidence in support of his view, and concluded that if the last change of level in south-west Lancashire was a downward one, it could not have taken place within 2500 years.

The Proteaceæ.—Count G. de Saporta has lately communicated to the French Academy an important note on the subject of the supposed presence of Australian forms of Proteaceæ in the European tertiaries. The Proteaceæ are at present limited to the Southern Hemisphere, and form two natural associations,—an Australian, including the genera *Petrophila*, *Grevillea*, *Lomatia*, *Banksia*, *Dryandra*, &c., which do not occur in Africa; and a South African represented by *Protea*, *Leucadendron*, *Leucospermum*, &c., which are not found in Australia. The plants which have been regarded as Proteaceæ in European deposits, from the late cretaceous of Aix-la-Chapelle upwards, have been referred to Australian genera such as *Grevillea*, *Lomatia*, *Banksia*, and *Dryandra*. Ad. Brongniart with some doubt indicated a *Stenocarpites* among the species brought from Koumi by Gaudry. M. de Saporta notices certain examples which render the identification of European fossil plants with the Australian types of Proteaceæ at least very doubtful. *Stenocarpites anisolobus*, Brongn., named by Saporta *Grevillea anisoloba*, has been recognized by Unger as representing the detached leaflets of a large Araliaceous leaf (*Cussonia polydrys*, Ung.). Nearly all the fossil leaves referred to *Grevillea* have a venation such as occurs in the Thymeleæ. Unger's *Dryandroides* and most of his *Banksites* are referred to the Myriceæ. *Dryandra Schrankii* (or *Comptonia dryandræfolia*) shows Myricaceous fructification. *Dryandra Contzeniana* and *primæva*, Deb. from the Senonian of Aix-la-Chapelle are probably *Comptoniæ*. *Dryandra Micheloti*, Wad. of the Paris Eocene and the Arkose of Brives, still, however, presents the characteristic physiognomy of *Dryandra*; but as M. de Saporta remarks, this shows how the evidence in favour of the Australian element in the European fossil flora has fallen off in value. No authentic fruit or seed has ever been found.

In the gypsum of Aix, in Provence, the *Lomatites*, especially *L. aquensis*, Sap., present a great resemblance to *Lomatia linearis* and *longifolia* of Australia, but this argument loses much of its force after comparison with the leaves of *Baccharis semiserrata*, De Cand. var. *glabra*, a Brazilian plant, of the order Compositæ. These leaves so closely resemble those of *Lomatites aquensis*, Sap., that it is hardly possible to resist the conclusion of a general affinity between the fossil and this living plant. Nevertheless there are differences which would lead to the formation of a section or subgenus peculiar to the Tertiary of Provence. The texture of the leaves must have been more coriaceous; the marginal teeth are spinescent, and the veins generally concealed. These peculiarities and the general form caused the fossil plant to be referred to *Lomatia;* but M. de Saporta thinks it more natural to recognize the plant as belonging to the Baccharideæ and to name it *Baccharites aquensis.* This view is supported by the occurrence of numerous achenes or fruit of Compositæ in the same beds with the leaves. These organs, known as *Cypselites*, include at Aix at least four species, *Cypselites gypsorum*, *stenocarpus*, *Philiberti*, and *varius.* The last two agree entirely in characters with the achenes of *Conyza* and *Baccharis;* the body of the fruit is more or less spindle-shaped at the base, narrowed above, truncate at the apex, where it bears a sessile pappus of which the simple, silky hairs appear to be arranged in a single series.

If these facts be accepted as definitive and lead to the abandonment of the notion that we have Proteaceæ of Australian type represented in Europe, we should get rid of a great anomaly. The presence in Europe of types of plants now exotic is generally in relation to the present geographical distribution of those types. In this way many well-characterized genera, some now specially African, others limited to certain parts of Asia, or North America, have certainly formerly inhabited Europe. Successive revolutions with gradual cooling of the climate, will explain the disappearances that have taken place: but the direct implantation in the heart of ancient Europe of a whole colony of plants, such as are now quartered in one part of the Southern Hemisphere, with no outposts in the intermediate space, requires for its acceptance the most absolute proof. (*Comptes Rendus*, 16th May, 1881.)

Affinities of Halysites.—Prof. Verrill refers to the various genera of so called 'tabulated corals,' which have lately had their true zoological positions determined. The hydroid nature of *Millepora* is now generally admitted; he has himself shown that *Pocillopora* and its allies are Madreporarian corals, and that *Favosites* and related extinct genera are closely related to the existing *Alveopora* and *Porites;* and Moseley, having ascertained the Alcyonarian affinities of *Heliopora*, has referred some fossil genera to the same position. With regard to *Halysites*, Prof. Verrill says, 'The affinities of the genus *Halysites*, the common "chain coral" of the Silurian, have hitherto been very doubtful. Within a few days Mr H. J. Woodman has shown me a very remarkable specimen of this genus in which the internal structure is beautifully preserved. In this example, which is a fragment [illegible] inches across, the large tubes contain [illegible] well-developed and regular septa extending to the centre. Their edges are slightly serrulate, and do not rise above the tabulæ. It shows that the structure is that of a true Madreporarian coral.' Mr. Woodman informed him that this specimen was a fragment from a larger mass eight or ten feet across, the greater part of which was like the common specimens, showing no septa, but here and there, in spots, all over the face of the mass, the septa were as well preserved as in the fragment.'

The Bears of the Caverns of Lherm.—M. Filhol has communicated to the French Academy (*Comptes Rendus*, April [illegible]), some interesting to the species of Bears found fossil in the bone-cave of Lherm, in the Ariège. Of the various mammals found in this cavern (*Ursus spelæus, Felis spelæus, Hyæna spelæa*, and species of *Rhinoceros, Cervus*, &c.), the Great Cave Bear (*Ursus spelæus*) is the most abundant, at least a hundred crania of that animal having been found. According to M. Filhol, these abundant materials prove the great fixity of character of the species, and whatever modifications some of them may show, they are always quite distinct from the common Brown Bear (*Ursus arctos*). Lately, M. Marty has found two skulls of Bears quite distinct from any that had previously been met with. One of them, a perfect skull, measures along its lower surface, from the incisor margin to the occipital foramen, 35 centim. (nearly 14 inches), and has six teeth behind the canine as in *Ursus arctos*, instead of only three as in *U. spelæus*. This piece of evidence is borne out by other characters; and M. Filhol identifies this animal with the living Brown Bear, which, therefore, he considers cannot have descended from the Great Cave Bear, but must have originated elsewhere, probably in North America, and gradually advanced to take the place of *U. spelæus* in Southern Europe, where it still occurs.

The other specimen is still more interesting. It consists of the anterior part of a bear's skull, having four teeth behind the canine in the upper jaw, and the first premolar separated from the canine by a space of 15 millim. Hence the face was very short, but it was remarkably wide. The width behind the carnassial tooth is 10·3 centim. The nasal aperture measures 64 millim. across, and only 51 from front to back, while in all other known bears the antero-posterior diameter is the longer. The forehead is depressed and nearly horizontally continuous with the nasal bones, its elevation above the palatine arch being only 10·8 centim. at a point where the forehead has an elevation of 11·8 centim. in the Brown Bear, and 18·3 centim. in the Great Cave Bear. The width of the forehead is nearly equal to that of the largest crania of *Ursus spelæus*. M. Filhol regards this fragment as indicating a new species of Bear, for which he proposes the name of *Ursus Gaudryi*.

A Jurassic Bird.—Prof. Marsh describes a fossil bird from the Jurassic *Atlantosaurus* beds of Wyoming, which will be the oldest representative of the class if *Archæopteryx* is to be regarded as Reptilian. Prof. Marsh names the species *Laopteryx priscus*. The type specimen consists of the posterior portion of the skull, which indicates a bird rather larger than a blue heron (*Ardea herodias*). The bones of the skull are pneumatic. The occipital condyle is sessile and hemispherical, flattened and slightly grooved above. The occipital foramen is nearly circular. The quadrate bone had an undivided head. In general character the skull seems most nearly to approach the Ratitæ. A single tooth was found in the matrix, resembling those of *Ichthyornis*. Prof. Marsh infers that *Laopteryx* possessed teeth and biconcave vertebræ.

MINERALOGY.

Plumosite in the Isle of Man.—In the *Transactions of the Royal Geological Society of Cornwall*, Mr. Warington W. Smyth notices the occurrence of plumosite in the Foxdale Mine, Isle of Man. The mineral is a double sulphide of lead and antimony, and its occurrence here is especially interesting as no antimonial minerals had previously been known from these mines, which furnish a richly argentiferous lead ore. Plumosite occurs in the Hartz, where it is known by the cognate name of *Federerz;* in Britain it is exceedingly rare. The specimens described by Mr. Warington Smyth consist, as usual, of very delicate fibres, which appear to be matted together like a tuft of dark cotton-wool. The microscope shows it to form prismatic crystals of brilliant metallic lustre.

Jadeite.—M. Damour has communicated to the Academy of Sciences (*Comptes Rendus*, 6th June, 1881) the results of some new investigations made by him upon jadeites and other sodiferous rocks. Jadeite is employed in India and China in the manufacture of vases and ornaments, and is also met with in the worked state in Europe, in prehistoric burial-mounds and caves.[*] The fact that no stone of the kind has ever been found in the rough state in Europe, has led to the assumption that the objects found here were imported by immigrants from the East, and M. Damour has investigated its geographical distribution with the view of clearing up the question of the real origin of the European jadeite axes and ornanents. M. Damour gives analyses of undoubted jadeites from Asia, and of portions of worked stone possessing the same characters obtained in Mexico, and in comparison with these some analyses of minerals obtained in Europe, especially in the region of the Alps, which he thinks make out a strong case in favour of the occurrence of jadeite in Europe. The following are the analyses of the European specimens:—

	I.	II.	III.	IV.	V.	VI.
Silica . .	58·51	56·45	57·99	55·82	56·74	54·53
Alumina . .	21·98	17·02	20·61	10·95	10·02	14·25
Ferric oxide .	1·10	7·62	2·84	5·68	4·69	3·29
Chromic oxide .	——	——	——	——	0·03	——
Lime . .	5·05	4·76	4·89	13·42	14·00	12·40
Magnesia . .	1·70	2·32	3·33	9·05	9·10	7·50
Soda . .	11·84	11·46	9·42	6·74	5·40	6·21
Potash . .	traces	traces	1·50	traces	traces	traces
	100·18	99·63	100·58	101·66	99·98	98·18
Spec. Grav.	3·35	3·17	3·16	3·22	3·32	3·31

No. I. is a specimen from Monte Viso, in Piedmont; II. from Ouchy, near Lausanne; III. is part of a stone axe; IV. is a rock from near St. Marcel, in Piedmont, where it was obtained from a small vein; V. from a pebble from the valley of Aosta; and VI. a green substance containing garnets, forming a vein in gneiss near Nantes.

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[*] See an article by F. W. Rudler in *Popular Science Review* for October 1879.

The author remarks upon the similarity of these minerals, both in character and composition, to the true jadeites, which are also generally found, not in position, but in the form of pebbles and blocks transported by glaciers or by running water. In Thibet there is no doubt that deposits of jadeite must exist, and the author infers that it also occurs in America, probably in Mexico and in the regions bordering on the Amazons. The analyses and observations given by him in his present paper would seem to show that the same mineral exists also on the European continent, probably in or near the chain of the Alps. If this be the case, there is no need to invoke a migration of ancient Asiatic populations to account for the presence of jadeite axes on this continent.

Geniculated Zircons.—Mr. W. E. Hidden describes and figures (*Silliman's Journal,* June 1881) twin crystals of zircon obtained by him from the new locality of apatite and sphene at Renfrew, Canada. The twinning plane is the same as in cassiterite and nitrite. The twin figured by him weighed over 35 grammes, and was remarkably perfect and had well-polished planes. Its colour was deep brown-lake, and it was transparent in spots. Previously described twins of zircon have been microscopic and questionable.

PHYSICS.

Electric Storage of Dynamical Energy.—The following article and letters, which have appeared in the *Times* during May and June, mark such an epoch in the history of electricity that they deserve reproducing *in extenso*:—

'We publish this morning a letter from Sir William Thomson, supplementary to that in which "F. I. R. S.," on the 16th of May, gave the first account of the conveyance from Paris to Glasgow of a box containing active electricity in a portable form; and it would certainly appear, from both communications, that applications of ever-widening utility are opening up before the most potent of natural forces, which seems to be rapidly becoming also the most manageable. Our readers will remember that "F.I.R.S." related how he witnessed in Paris, on the 9th of May, the charging of four of Faure's batteries with electricity obtained from an ordinary Grove's battery. The four batteries were enclosed in a wooden box, about a cubic foot in measurement, and weighing, with its contents, about 75 lbs. This box of "electric energy" was handed by M. Faure to our correspondent, who brought it with him across the Channel, and, after seventy-two hours of travelling, delivered it to Sir William Thomson at Glasgow, in order that the power of its charge might be made the subject of observation and experiment. The box was believed to contain electricity in quantity equivalent to a million foot pounds; and we now hear that this belief has been fully borne out by experiment. No appreciable loss was incurred during the transit; and the energy put into the four batteries in Paris remained in them *until it* [illegible]ied to working purposes in Glasgow. So completely was the apparatus under command that one of the four batteries was detached from the rest, and carried to another place to supply the force required for an electric cautery. A single battery, when recharged, was left alone for ten days, and then it yielded to Sir William Thomson 260,000 foot pounds, so that the original estimate of a million foot pounds for the whole box was probably somewhat under the mark. Further investigations are required in order to discover what are the limits, if any, of the power to preserve electric energy unwasted; but sufficient is known to show that it can be preserved long enough for many important practical applications. That which Sir William Thomson regards as likely to be the first, at least in point of time, is the use of Faure's batteries in private houses, as reservoirs of electricity for domestic purposes, such as lighting, heating, working of sewing machines, so that no interruption of action would be produced by a temporary interruption of the electric supply given by any main engine from which it was derived.

'Sir William Thomson reminds us that the storage of force to be afterwards put to practical uses is a very old contrivance, of which we may see an illustration in the winding of a watch; and also the storage of electricity has long been familiar to men of science as a theoretical possibility. There is often a long step, however, from theoretical possibility to practical achievement; and what we are now called upon to notice is no longer that such a storage may perhaps be accomplished at some future time, but that it has actually been accomplished upon what may almost be called a working scale. Many philosophers are of opinion that electricity, at no distant date, will entirely supersede fires for cooking and heating, steam as a motor, and gas and oil as illuminants; but hitherto it has been felt as a great difficulty, economical rather than scientific, that the agents proposed to be superseded were themselves actually employed to produce the electricity. It has been asserted, moreover, that the sectional area of the metallic conductors required to deliver electricity in quantities suited to the requirements of town communities would have to be enormously large, and in a corresponding degree costly; and that difficulties with regard to insulation would be of constant occurrence. But electricity is to be obtained from the atmosphere by simple mechanical means wherever any kind of motive power is available; and, if it can be stored in portable batteries and carried about for use, there seems to be no reason why it should not be obtained in very cheap ways, as by wind or water mills, by mechanical contrivances for utilizing the ebb and flow of the tides, or by other applications of the power which nature everywhere offers for the use of man, and which is so frequently suffered to run waste.'

'SIR,—The marvellous "box of electricity" described in a letter to you, which was published in the *Times* of May 16, has been subjected to a variety of trials and measurements in my laboratory for now three weeks, and I think it may interest your readers to learn that the results show your correspondent to have been by no means too enthusiastic as to its great practical value. I am continuing my experiments to learn the behaviour of the Faure battery in varied circumstances, and to do what I can towards finding the best way of arranging it for the different kinds of service to which it is to be

At the request of the Conseil d'Administration of the Société de la Lumière, I have gladly undertaken this work, because the subject is one in which I feel intensely interested, seeing in it a realization of the most ardently and unceasingly felt scientific aspiration of my life—an aspiration which I scarcely dared to expect or to hope to live to see realized.

'The problem of converting energy into a preservable and storable form, and of laying it up in store conveniently for allowing it to be used at any time when wanted, is one of the most interesting and important in the whole range of science. It is solved on a small scale in winding up a watch, in drawing a bow, in compressing air into the receiver of an air-gun or of a Whitehead torpedo, in winding up the weights of a clock or other machine driven by weights, and in pumping up water to a height by a windmill (or otherwise, as in Sir William Armstrong's hydraulic accumulator) for the purpose of using it afterwards to do work by a waterwheel or water pressure on a piston. It is solved on a large scale by the application of burning fuel to smelt zinc, to be afterwards used to give electric light or to drive an electro-magnetic engine by becoming, as it were, unsmelted in a voltaic battery. Ever since Joule, forty years ago, founded the thermodynamic theory of the voltaic battery and the electro-magnetic engine, the idea of applying the engine to work the battery backwards, and thus restore the chemical energy to the materials so that they may again act voltaically, and again and again, has been familiar in science. But with all ordinary forms of voltaic battery the realization of the idea to any purpose seemed hopelessly distant. By Planté's admirable discovery of the lead and peroxide of lead voltaic battery, alluded to by your correspondent, an important advance towards the desired object was made twenty years ago; and now by M. Faure's improvement practical fruition is attained.

'The "million of foot pounds" kept in the box during its seventy-two hours' journey from Paris to Glasgow was no exaggeration. One of the four cells, after being discharged, was recharged again by my own laboratory battery, and then left to itself absolutely undisturbed for ten days. After that it yielded to me 260,000 foot pounds (or a little more than a quarter of a million). This not only confirms M. Reynier's measurements, on the face of which your correspondent's statement was made; it seems further to show that the waste of the stored energy by time is not great, and that for days or weeks, at all events, it may not be of practical moment. This, however, is a question which can only be answered by careful observations and measurements carried on for a much longer time than I have hitherto had for investigating the Faure battery. I have already ascertained enough regarding its qualities to make it quite certain that it solves the problem of storing electric energy in a manner and on a scale useful for many important practical applications. It has already had in this country one interesting application, of the smallest in respect to dynamical energy used, but not of the smallest in respect to beneficence, of all that may be expected of it. A few days ago my colleague, Prof. George Buchanan, carried away from my laboratory one of the lead cells (weighing about 18 lbs.) in his carriage, and by it ignited the thick platinum wire of a galvanic *écraseur* and bloodlessly removed a nævoid tumour from the tongue of a young boy in about a minute of time. The operation would have occupied over ten minutes if performed by the ordinary chain *écraseur*, as it must have been had the Faure cell not been available, because, in the circumstances, the surgical electrician, with his paraphernalia of voltaic battery to be set up beforehand, would not have been practically admissible.

'The largest useful application waiting just now for the Faure battery—and it is to be hoped that the very *minimum* of time will be allowed to pass till the battery is supplied for this application—is to do for the electric light what a water cistern in a house does for an inconstant water supply. A little battery of seven of the boxes described by your correspondent suffices to give incandescence in Swan or Edison lights to the extent of one hundred candles for six hours, without any perceptible diminution of brilliancy. Thus, instead of needing a gas-engine or steam-engine to be kept at work as long as the light is wanted, with the liability of the light failing at any moment through the slipping of a belt—an accident of too frequent occurrence—or any other breakdown or stoppage of the machinery, and instead of the wasteful inactivity during the hours of day or night when the light is not required, the engine may be kept going all day and stopped at night, or it may be kept going day and night, which will undoubtedly be the most economical plan when the electric light comes into general enough use. The Faure accumulator, always kept charged from the engine by the house-supply wire, with a proper automatic stop to check the supply when the accumulator is full, will be always ready at any hour of the day or night to give whatever light is required. Precisely the same advantages in respect of force will be gained by the accumulator when the electric town supply is, as it surely will be before many years pass, regularly used for turning lathes and other machinery in workshops and sewing machines in private houses.

'Another very important application of the accumulator is for the electric lighting of steamships. A dynamo-electric machine of very moderate magnitude and expense, driven by a belt from a drum on the main shaft, working through the twenty-four hours, will keep a Faure accumulator full, and thus, notwithstanding irregularities of the speed of the engine at sea or occasional stoppages, the supply of electricity will always be ready to feed Swan or Edison lamps in the engine-rooms and cabins, or arc lights for mast-head and red and green side lamps, with more certainity and regularity than have yet been achieved in the gas supply for any house on *terra firma*.

'I must apologize for trespassing so largely on your space. My apology is that the subject is exciting great interest among the public, and that even so slight an instalment of information and suggestions as I venture to offer in this letter may be acceptable to some of your readers.

'I remain, your obedient servant,

'William Thomson.

'*The University, Glasgow, June* 6.'

'Sir,—Although agreeing with every word of Sir William Thomson's letter in the *Times* of to-day, and entirely sympathizing with his enthusiasm as regards the marvellous box of electricity, still I feel that it would have been desirable if, in pointing out the importance of this new discovery, Sir William Thomson had guarded against a very probable misconstruction of the purport of his letter.

'The means of storing and re-storing mechanical energy form the aspiration not only of Sir William, but of every educated mechanic. It is, however, a question of degree—of the amount of energy stored as compared with the weight of the reservoir, the standard of comparison being coal and corn. Looked at in this way, one cannot but ask whether, if this form of storage is to be the realization of our aspirations, it is not completely disappointing. Large numbers are apt to create a wrong impression until we inquire what is the unit. Eleven million foot pounds of energy is what is stored in 1 lb. of ordinary coal. So that in this box, weighing 75 lbs. there was just as much energy as in 1½ oz. of coal, which might have been brought from Paris, or anywhere else, in a waistcoat pocket, or have been sent by letter.

'When we come to the question of the actual conveyance of energy for mechanical purposes, this view is of fundamental importance. The weight of the same amount of energy in the new form is 800 times greater than the equivalent amount of coal; and as a matter of economy, supposing that energy in this form might be had at a certain spot, and no capital were required for its conversion or storage, and that the energy were directly applicable, it could not be carried ten miles, that is to say, such energy cannot be economically useful ten miles from its source, although coal had to be carried one hundred miles to the spot. This limit, in truth, falls far short of what has been already attained by other means. By wire ropes and by compressed air or steam energy may be economically transmitted from ten to twenty miles. So that if this is the utmost of what is to be done by means of the storage of electricity, this discovery adds another door to those which are hopelessly closed against the possibility of finding in Niagara or other water-power a substitute for our coal, even when the object is motive power, and much more for that purpose for which five-sixths of our coal is used—the production of heat.

'It is very important that the people of this country should not shut their eyes to the fact that so far from there being a greater prospect of the solution of the problem than when, about twenty years ago, Prof. Jevons raised the alarm, the prospect is now much smaller. In the meantime the capabilities of steel ropes, fluids in pipes, and electricity along conductors, have been not only investigated, but practically tested and found altogether wanting. And now, it would seem, that the storage of electricity must be added to the list.

'OSBORNE REYNOLDS.

'*Owens College, June* 9.'

'SIR,—Your leading article in the *Times* of yesterday on the storage of electricity alludes to my having spoken of Niagara as the natural and proper chief motor for the whole of the North American Continent. I value the allusion too much to let it pass without pointing out that the credit of originating the idea and teaching how it is to be practically realized by the electric transmission of energy is due to Mr. C. W. Siemens, who spoke first, I believe, on the subject, in his Presidential Address to the Iron and Steel Institute in March, 1877. I myself spoke on the subject in support of Mr. Siemens's views at the Institution of Civil Engineers a year later. In May, 1879, in answer to questions put to me by the Select Committee of the House of Commons on Electric Lighting, I gave an estimate of the quantity of copper conductor that would be suitable for the economical transmission of power by electricity to any stated distance; and, taking Niagara as example, I pointed out that, under practically realizable conditions of intensity, a copper wire of half an inch diameter would suffice to take 26,250-horse power from water-wheels driven by the Fall, and (losing only twenty per cent on the way) to yield 21,000-horse power at a distance of 300 British statute miles; the prime cost of the copper amounting to 60,000*l*., or less than 3*l*. per horse-power actually yielded at the distant station.

'I remain, Sir, your obedient servant,

'WILLIAM THOMSON.

'*The University, Glasgow, June* 9.'

'SIR,—Prof. Osborne Reynolds' letter in your issue of Saturday, the 11th inst., shows that the first idea that has occurred to him on reading Sir William Thomson's letter on Faure's "electric store," is probably what must have suggested itself to many engineers, viz., that so far from a million foot pounds being a surprisingly large amount of energy to be stored up in a mass of 75 lbs., it is really extremely small; and, indeed, while crossing over from Paris at the commencement of last week, I could not help thinking that the passengers were bringing to England literally in the smuts and blacks on their coats far more energy than had ever been imported into this country stored up in Faure's secondary batteries. But although it is perfectly true, as Prof. Reynolds says, that 1½ oz. of coal contains about one million foot pounds of work stored up in it, this is by no means all that has to be taken into account in considering this question; for where is the engine for extracting this million foot pounds of work out of the 1½ oz. of coal? Indeed, as Prof. Reynolds would himself tell us, we cannot get much more than one-tenth of this amount of work out of the 1½ oz. of coal even in our largest steam-engines, which burn many pounds of coal per minute, and in which much heat is wasted in getting up steam. And if we come to the burning of one single 1½ oz. of coal, I know of no engine that can obtain from this even one thousand foot pounds of work, or one thousandth of the energy contained in the coal, if no other coal be used in getting up steam or in previously heating the engine.

'But if a secondary battery be allowed to drive a magneto-electro-motor or a dynamo-electric machine with separate exciter only even for the short time necessary to develope, say, thirty foot pounds of mechanical work, I anticipate this can be done without using up in the whole process more than about thirty-five foot pounds of the electric energy stored up in the reservoir, since the experiments of Prof. Perry and myself have shown that, when the motor is running at high speeds with a light load, as much as ninety-three per cent of the electric energy put into a magneto-electro-motor is given out again as mechanical work measured by an absorption dynamometer.

'It may be answered, however, that if a small bit of coal, although containing a vast store of energy, is not of much practical use in producing work, in consequence of the absence, up to the present time, of a proper converter of the coal's energy into mechanical work, at any rate a small galvanic battery (a little Daniell's cell, for example) is not only a vast storehouse of power, but contains a store which we have the means of converting without appreciable loss into electric light or mechanical work. How, then, is a Faure's box a better store of electric energy than a little Daniell's cell? This question has precisely the same answer as "Why is a pinch of dry gunpowder better than a pinch of wet?" Not because the dry gunpowder has more energy in it than the wet, but because the energy stored up in the dry gunpowder can be all, if we wish, used up quickly, and an explosion produced, whereas that in the wet can only be utilized bit by bit. So seven Faure's boxes will illuminate one hundred Swan lamps for six hours, while seven Daniell's cells, or, indeed, twice that number, although possessing a store of power millions of times as great as that in Faure's boxes, will not illuminate a single Swan light.

'But while fully recognizing the great advance made in the subject by Planté, and the recent improvements introduced by Faure, I do not wish to give the impression that the problem is by any means completely solved, since, if the attempt that Mr. Perry and myself, no doubt like many other electricians, are making to convert at a low temperature the energy in coal into electric energy, meets with even a fairly satisfactory solution, then a fragment of coal, or, it may be, a puff of gas rich in carbon or carbonic oxide, will be a practical store of energy of incomparably greater value than any secondary battery.

W. E. Ayrton.

'*The City and Guilds of London Technical College,*
'*Finsbury, June* 13.'

Globe Lightning.—M. Trécul records that on August 25, 1880, during a thunder-storm in the day-time, he saw a very brilliant, luminous body issue from a dark cloud. It was nearly white, having only a slight yellowish tinge, was distinctly circumscribed, slightly elongated in form, and had the appearance of being 35–40 centims. long and about 25 centims. wide. The two ends were somewhat conical. This body was visible only for a few moments, when it disappeared seemingly by entering again into the cloud, but before its disappearance, it threw off a small quantity of its substance, *which fell vertically like a heavy body*, leaving behind it a luminous train, at the edges of which were reddish sparks, or rather globules, for their light was not radiant. The upper part of the train became sinuous. The little falling body divided and soon afterwards became extinguished just before it passed down behind the houses. No sound was heard, although the cloud was not distant. (*Comptes Rendus*, 28th March, 1881.)

The Speed of Thought.—It is not unusual to hear the expressions, 'quick as thought' and 'quick as lightning,' used as if they were synonymous; but there is a vast difference, comparatively speaking, between them. The electric impulse is practically instantaneous over, say, a mile of wire; but, if we may trust the experiments of Helmholtz and others, the wave of thought requires about a minute to traverse a mile of nerve. An electric shock is felt simultaneously in every part of the body, but the sensations of touch and of pain occupy an appreciable time in making their impressions on the sensorium. The interval between the reception of an impression by the brain, and its perception by that organ, is, doubtless, inexpressibly short; but as we can only test the speed of thought by noting the time elapsing between the application of the cause of the thought and the exhibition of some indication of its reception, we find that the time occupied can be measured. Thus Hirsch, by means of a suitable apparatus, found that a touch upon the face was recognized and responded to by a predetermined signal operated by hand in one-seventh of a second. There is no doubt some loss in the purely mechanical operation of making the signal; but when the different senses are tested in this manner, and a mean taken of all the experiments, we find not only that the act of thinking is not so rapid as was imagined, but that the speed varies with different senses. Thus the sense of touch was found to respond in one-seventh of a second, that of hearing required one-sixth of a second to respond, and when the eye was tested, one-fifth of a second was occupied in recognizing the signal. The distances travelled by the nervous impulses in each of these cases, was as nearly as possible the same, and it follows therefore that the recognition of them required more time in some cases than in others. Simple as it may seem, a number of operations must be performed by the brain in receiving and recording the reception of the impression. There is the transmission of the sensation to the brain, its recognition, and then the determining to make the signal, the transmission of the determination to the muscles, and the movement of those muscles. Hirsch showed, as explained above, that less time was required to recognize a touch than a sound, and that it took more time to see than to hear, but the question still remained as to what part of the time occupied was consumed in the act of recognition. Donders, by means of some very ingeniously constructed apparatus, solved the question. He found that the double act of recognizing a sound and giving the response, occupied seventy-five thousandths of a second, of which forty thousandths were occupied in simple recognition, leaving thirty-five thousandths for the act of volition. One twenty-fifth of a second was occupied in judging which was first of two irritants acting upon the same sense; but a slightly longer time was necessary to determine the priority of signals sent by different senses, as those of hearing and seeing. These results were obtained from a man of middle age, the young were slightly quicker; but the average of many experiments showed that the time required for a simple thought was never less than the fortieth of a second. From these experiments we learn that the mind cannot perform more than twenty-four hundred simple acts in a minute, and that the stories we have heard from persons rescued from drowning are simply exaggerations.

ZOOLOGY.

Paired Fins of Sharks and Rays.—Mr. F. M. Balfour lately read before the Zoological Society a paper on the development of the skeleton of the paired fins of Elasmobranchs, considered in relation to its bearings on the nature of the limbs of the Vertebrata. The object of the investigations recorded in this paper was explained by the author to be twofold,—viz., on the one hand to test how far the study of the development of the skeleton of the fins supported the view which had previously been arrived at by the author to the effect that the paired fins were the specialized and highly developed remnants of a once continuous lateral fin on each side; and on the other to decide between the views of Gegenbaur and Huxley, and Thacker and Mivart, as to the primitive type of fin-skeleton. The author pointed out that the results of his researches were entirely favourable to the view that the paired fins were structures of the same nature as the unpaired; and that they gave a more general support to the views of Thacker and Mivart. They clearly showed that the pelvic fins retain a more primitive character than the pectoral. Conclusions were drawn somewhat adverse to the views recently put forward on the structure of the fin by Gegenbaur and Huxley, both of whom considered the primitive type of the fin to be most nearly retained in *Ceratodus*, and to consist of a central multisegmented axis with numerous rays on its two sides. It appeared, in fact, that the development of the skeleton demonstrates that a biserial type of fin like that of *Ceratodus* could not have been primitive, but that it must have been secondarily derived from a uniserial type, by the primitive bar along the base of the fin (the *basipterygium*) being rotated outwards, and a second set of rays being developed on its posterior border.

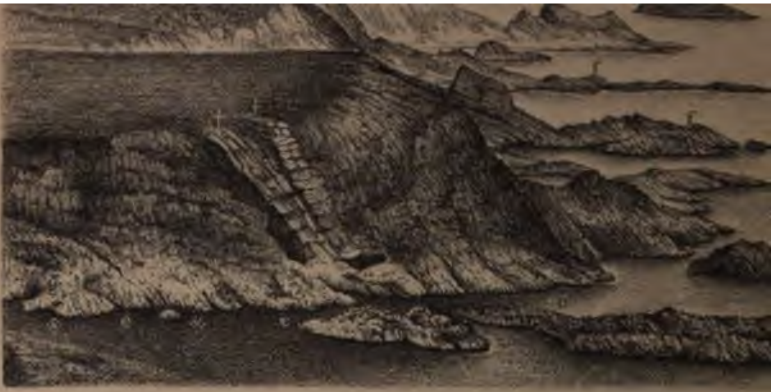

FIG 1. EAST SIDE OF PORTH-Y-RHAW.

THE CLASSIFICATION OF THE EOZOIC AND LOWER PALÆOZOIC ROCKS OF THE BRITISH ISLES.

By HENRY HICKS, M.D., F.G.S., &c.

[Plates VII. and VIII.]

THE additions which have been made to our knowledge in regard to the history and classification of the older rocks in Great Britain of late years have been very numerous, and yet but few attempts have been made to array them in systematic order, so that their importance may be readily recognized. The most elaborate account recently placed before the Geological world is the address of the President of the Geological Society (R. Etheridge, Esq., F.R.S.), published in the May number of the *Quarterly Journal.* An admirable paper, also, on a portion of these rocks, by Professor C. Lapworth, F.G.S., appeared in the June and July numbers of the *Geological Magazine* for this year.* In the present paper I propose to give a brief connected statement of the present state of our knowledge of these rocks, and the classification which appears to me the most natural one. Some new names will, of necessity, have to be added to explain local subdivisions, but in regard to the larger formations the terms which have been generally used in my papers of late years appear at present to be sufficient to include all the rocks explored.

Part I.

Eozoic (Pre-Cambrian).

For the sake of uniformity in the names for the larger periods in geological chronology, I adopt here the term which

* See also papers by the Author, *Quart. Journ. Geol. Soc.* vols. xxxi., xxxiii., xxxiv., and xxxv.; *Proceedings Geol. Assoc.* vols. iii. and vii.; and *Geol. Mag.* Decade II. vols. iii. and vi.

has been used for some time by American authors for the rocks known under the several names of Pre-Cambrian, Archæan, or Primary. Possibly none of the names hitherto suggested can remain in the face of future discoveries; but as long as the term *Palæozoic* continues to be so universally used for the succeeding period, the term *Eozoic* is probably the best that can at present be applied to this more ancient one.

The Eozoic rocks in Britain have of late years received a considerable amount of attention, and much additional information concerning them has in consequence been obtained. Up to a recent period it was supposed that with the exception of a narrow strip along the north-west coast of Scotland and in the Hebrides, there was no satisfactory evidence of the presence of these primary rocks anywhere in Britain. Stratified crystalline rocks had been noticed in other areas, but these were almost universally placed among much more recent deposits, either on theoretical grounds or by misconceptions in stratigraphy. With the exception of careful stratigraphical work nothing has tended so much of late to advance our knowledge in regard to these early rocks, as the recognition of the fact that the metamorphism of great groups of strata does not take place so readily as was formerly supposed, and that it is now tolerably clear that some special conditions, such as do not appear to have prevailed to any great extent over the British areas since the Pre-Cambrian (Eozoic) period, were necessary to produce such results. The unravelling of the history of these primitive rocks is fraught with many difficulties, and in the absence of organic remains the correlation of the groups in different areas is seldom as satisfactory as could be desired. But that there are special characters present which tend to distinguish each important group over wide areas there can be no doubt; and when we look closely into these, and at the same time take note of any influence which local physical conditions may have exerted, we can generally arrive at a tolerably satisfactory correlation.

We now divide the Eozoic rocks which are exposed in the British areas into four distinct formations under the names of Lewisian, Dimetian, Arvonian, and Pebidian.

1. *Lewisian.*

The oldest stratified rocks apparently in this country are some gneiss rocks, found chiefly in the Hebrides and along the north-west coast of Scotland, also probably along the north-west coast of Ireland, and perhaps in the Malvern Hills in England. Many years ago Sir R. Murchison expressed the opinion that these gneiss rocks along the north-west coast of

Scotland were the oldest in Great Britain, and, as far as we know at present, this view seems to be correct. He at first associated them with the Laurentian rocks of Canada; but though this correlation is possibly correct, he yet wisely grouped them under the local name Lewisian, after the island of Lewis, where they are largely developed. Dr. Sterry Hunt and myself have at different times pointed out the presence of these rocks in Ireland, and Dr. Holl has done the same in the Malvern Hills. The special characters which distinguish this group may be said to be the prevalence of very highly crystalline rocks, usually massive granitic gneisses, with red felspar and hornblende as their chief minerals, and quartz and mica in small proportion only. The normal strike is about east and west, but it varies to north-west and south-east.

Though but little additional information in regard to these rocks has been recently obtained, we are now better able, in consequence of the very important discoveries made of late years in other Eozoic rocks of Britain, to realize their importance in the classification, as well as the value of the formation in relation to the early history of these islands.

2. *Dimetian.*

This formation, like the above mentioned, consists chiefly of highly crystalline gneissic rocks, the prevailing types, however, being the so-called granitoid rocks, made up largely of quartz with some pinkish or white felspar. Hornblende is much less abundant than in the Lewisian rocks, but mica is more frequently met with. It may be said to consist chiefly of acid types of rocks, whilst the former is made up mainly of basic types. Bands of limestone, hornblende, chloritic, and micaceous schists occur occasionally in this formation.

The name Dimetian was first given by me to the group of granitoid and gneissic rocks which had been discovered by the late Mr. Salter and myself, underlying the Cambrian rocks at St. David's, in Pembrokeshire. Since then many additional areas of these rocks have been found, and the formation has been shown to consist of several important groups. In each area certain general resemblances in mineral characters are found to prevail, and these, combined with the physical evidences of contemporaneous deposition, are all the aids we can expect to find in our attempt at correlating such ancient rocks in different areas. That such evidences are important also is clear if we recognize the fact that the rocks must have been for the most part deposited in successive layers of various materials, like the alternating sediments in more recent groups, and in each case under tolerably similar physical conditions; that they also must have suffered changes in proportion to their age, and that the evidences of these changes, which could not have affected more recent deposits, are usually sufficiently well marked to be readily recognized.

I have described rocks belonging to this formation in Anglesey, Caernarvonshire, and many parts of Scotland; and Prof. Bonney and Dr. Callaway have noticed them in Shropshire.

The series may be advantageously divided into Upper and Lower groups: the Upper represented by the so-called quartz schists of Porthlisky, St. David's, and probably by the thin quartzose gneisses and mica schists of Gairloch and Ben Fyn, Scotland; and the Lower, by the massive granitoid and gneissic rocks of Bryn-y-Garn, St. David's, and Twt Hill, Caernarvon, and probably also of parts of Ben Fyn and the mountains at the head of Loch Shiel in Scotland. I propose for the groups the local names Porthlisky and Bryn-y-Garn.

The prevailing strike in the formation is from N.W. to S.E.

3. *Arvonian.*

This name was given by me in 1878 to a group of rocks, in some important particulars unlike the Dimetian, though up to that time it had been included in that formation. Subsequent researches in North and South Wales have revealed the fact that this is one of the most important of the Pre-Cambrian formations. In Pembrokeshire it occupies large areas (see Sect. 2 and 3, p. 308), and is there found to consist mainly of highly siliceous rocks, of the type called by the Swedish geologists 'hälleflinta.' Breccias, quartz-felsites, and other quartzo-felspathic rocks, also enter largely into its composition. In Caernarvonshire, as I have shown in previous papers, many important ridges, such as the Rivals, and those to the north and south of Llyn Padarn, and between Twt Hill, Caernarvon, and Bangor, consist almost entirely of rocks belonging to this formation. In Anglesey, I pointed out in 1878 an area of these rocks near Ty Croes. This I have since found, in company with Prof. Hughes, to extend much further to the north than I at first supposed, in fact as far as Bodafon Mountain. At the latter place the 'hälleflintas' are perhaps better exposed, and more nearly of the type of those in Pembrokeshire, than in any other place in North Wales.[*] In my former paper I mentioned, in describing the Pebidian rocks of the west coast of Anglesey, that 'possibly some, such as the rocks of Holyhead Mountain may prove to be of different age and probably older

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[*] Since I examined these rocks with Prof. Hughes, Prof. Bonney, in an appendix to an interesting paper by Dr. Callaway (*Quart. Journ. Geol. Soc.*, May 1881), has published some notes on these rocks which seem to confirm *the above* view. They are, however, called by him 'Quartz-schists.' In Dr. *Callaway's* map much too small an area is given to these rocks.

(Dimetian?)' I have since then carefully re-examined these rocks, and have come to the conclusion that they should be included rather with the Arvonian. Whether they occupy a higher or a lower, or an equivalent position to those of Bodafon Mountain, it is difficult at present to decide. Still the evidence seems to point to the quartz group at Holyhead being the highest. At St. David's, rocks like those of Holyhead exposed near Llanhowel are, I believe, higher in the succession than the more typical 'hälleflintas' of Treffgarn Rock. The strike is usually somewhere near north and south. This formation may be divided into two groups under the names of Treffgarn and Holyhead.

4. *Pebidian.*

This is a formation undoubtedly of enormous thickness, as may be seen from its partial exposure at St. David's (Sect. 1, p. 308), and contains several groups of rocks, in some respects considerably unlike each other. At present, however, it may be sufficient to divide the formation into two main groups. The lower one consists of the thin-bedded gneissic, micaceous, and talcose rocks; and the higher, of the brecciated rocks with their associated schists and slates. At St. David's the lower group is either but partially exposed or cut off by a fault. Some of the beds may be seen at Porthlisky Harbour resting unconformably upon the Dimetian axis. These are rather highly felspathic; others are the so-called talcose rocks, found frequently at this horizon in Canada, and described by Dr. Sterry Hunt as the 'commonly called talcose or nacreous schists, owing their peculiar characters to a soft, hydrous mica, which is not unfrequently disseminated in very quartzose beds and gives to such a schistose character.' Exactly similar rocks to these at Porthlisky occur at Dulas Bay, on the north coast of Anglesey; and I believe it will be found that they occupy a low position in relation to the chlorite-schists so well developed in that island. That the chlorite-schists in Anglesey, with a general north-east and south-west strike, belong to a period in the history of the globe not far removed from that indicated by the Lower Pebidian rocks of St. David's, I feel convinced. The deposits are sufficiently alike in material and in the changes they have undergone to be correlated. That they should now appear to be rather too much altered for this period, is probably due to the readiness of the chief materials entering into their composition to undergo change as compared with those in many of the other rocks. The view put forward by Sterry Hunt and Delesse, that 'talcose and chloritic rocks have been directly formed from the molecular re-arrangement or *diagenesis* of aqueous magnesian sediments,' seems to be the correct one, and to be capable of explaining many of the apparent difficulties in connexion with these old rocks. That some of these chlorite and talc schists occur at various other horizons in the Pebidian, alternating with clay slates, quartz rocks, breccias, and conglomerates, is beyond doubt; and I may mention as spots where these alternations may be well observed, the valley of St. David's, north of the Cathedral, Treginnis, near St. David's, where they occur, as in Anglesey, in association with serpentinous limestone, and Amlwch in Anglesey. It is certain, therefore, that though the larger portion of the Anglesey schists may belong to the lower group of the Pebidian, they are not restricted to that horizon. This partial metamorphism, visible chiefly in rocks most susceptible of change, is highly characteristic of the Pebidian formation wherever it is exposed in Britain. It is sufficiently marked to separate the formation clearly from the succeeding Cambrian; and, on the other hand, it is too imperfect to cause any confusion between the majority of the rocks in this formation and the more completely crystalline groups belonging to the Dimetian or Lewisian.

The upper group is largely made up of brecciated rocks alternating with purplish, reddish, and greenish slates and schistose rocks. Indurated volcanic ashes, lava-flows, and bands of limestone and serpentine occur in both. It may be well to designate these groups by local names, and I propose therefore to call the upper the Treginnis group from being largely exposed at that place, on the shore of Ramsey Sound, near St. David's; and the lower, the Menai group, after the Menai Straits, where they are well displayed. The prevalent strike in this formation is from north-east to south-west.

This formation occurs in many parts of Scotland, especially in the Grampians; and it is also found, according to Dr. Hunt, in the north-west of Ireland, about Lough Foyle. It occurs also in Charnwood Forest, in Shropshire, in the Malvern Hills, and probably also in Cumberland and in Cornwall. The following table will explain the supposed order in which the Eozoic rocks occur in this country:—

PERIOD.	SYSTEMS OR FORMATIONS.	GROUPS.	CHIEF PETROLOGICAL CHARACTERS.	CHIEF LOCALITIES WHERE EXPOSED.
EOZOIC.	PEBIDIAN.	Treginnis .	Conglomerates, Breccias, Schists, and Slates. Contemporaneous Lava Flows and Volcanic Ashes. Limestones and Serpentines.	St. David's, Anglesey, Caernarvonshire, and Harlech Mountains in Wales. Fort William and Grampians in Scotland. Lough Foyle, Ireland. Charnwood Forest, Wrekin, Malvern, &c.
		Menai . .	Breccias, Chloritic, Talcose, Felspathic, and Micaceous Schistose Rocks. Limestones and Serpentines.	St. David's, Anglesey, and Lleyn Promontory, Caernarvonshire. Grampians in Scotland.
	ARVONIAN.	Holyhead .	Schistose and Compact Quartz Rocks.	Llanhowell, near St. David's, and Holyhead Mountain in Anglesey.
		Treffgarn .	Breccias, Hälleflintas, and Quartz Felsites.	Treffgarn Mountain, Roch Castle and near St. David's in Pembrokeshire, Bodafon Mountain and Ty Croes in Anglesey, and several ridges in Caernarvonshire.
	DIMETIAN.	Porthlisky	Highly Quartzose Gneissic Rocks, with Limestone Bands.	Porthclais and Porthlisky near St. David's, Anglesey, and North-western Highlands of Scotland.
		Bryn-y-garn	Granitoid and Gneissic Rocks. Usually of a white, light grey, greenish, or pinkish colour.	St. David's and Brawdy in Pembrokeshire, Twt Hill, and Rhos Hirwain, Caernarvonshire, Anglesey, and North-western Highlands of Scotland.
	LEWISIAN.	. . . . .	Massive Hornblendic Gneiss, with but little Quartz or Mica. Of a black, dark grey or rusty colour.	The Hebrides and North-west Coast of Scotland, North-west of Ireland, and Malvern Hills in England.

Part II.

Lower Palæozoic.

It is not intended to burden this paper with a long history of the various classifications which have been adopted for these rocks from time to time; for classifications must necessarily vary with advancement of knowledge. All hard and fast lines, or the slavish adherence to any arrangement founded only in history and not in truth, are here, as in all other matters, barriers to progress. Numerous papers, however, on the question of history have of late been published, to which the reader may refer.*

The nomenclature will of necessity in some cases have chiefly a local significance, but as many of the groups have been at present little more than locally examined, this is almost unavoidable. Many of the names, however, are somewhat historical in their application, and have been so frequently used that they are now tolerably well known. The formations to be described are the Cambrian, Ordovian, and Silurian.

1. *Cambrian.*

Wherever these rocks are found in this country in contact with the Eozoic formations, they are unconformable to the latter. Fragments of the older rocks are also found in them in abundance, and evidence that they must have been built up chiefly from the denudation of the Eozoic rocks is everywhere apparent.

The name Cambrian, for these oldest Palæozoic rocks, was first used by Prof. Sedgwick, and it was he who laid the foundation for all future discoveries in these rocks. It is impossible to speak too highly of the value of his researches amongst these at that time barren strata; and if we cannot at present accept fully the divisions, or subdivisions, which he proposed, we reject them with much regret, and because their retention would greatly tend to retard the progress of science.

This formation may with advantage be divided into two main portions, with several groups in each.

The *Lower Cambrian* has a natural base made up of massive conglomerates and sandstones (see Sect. 1, p. 308); its upper boundary is well defined by an important palæontological break. It is

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* See Hunt, *Canadian Naturalist*, 1872, and *Geol. Essays*, 1878; Etheridge, *Quart. Journ. Geol. Soc.* May, 1881; Marr, *Geol. Mag.* June 1881; Lapworth, *Geol. Mag.* June and July, 1881; and Hicks, *Proceedings Geol. Assoc.* 1873, *Quart. Journ.* Geol. Soc. 1875, and Geol. Mag. 1878.

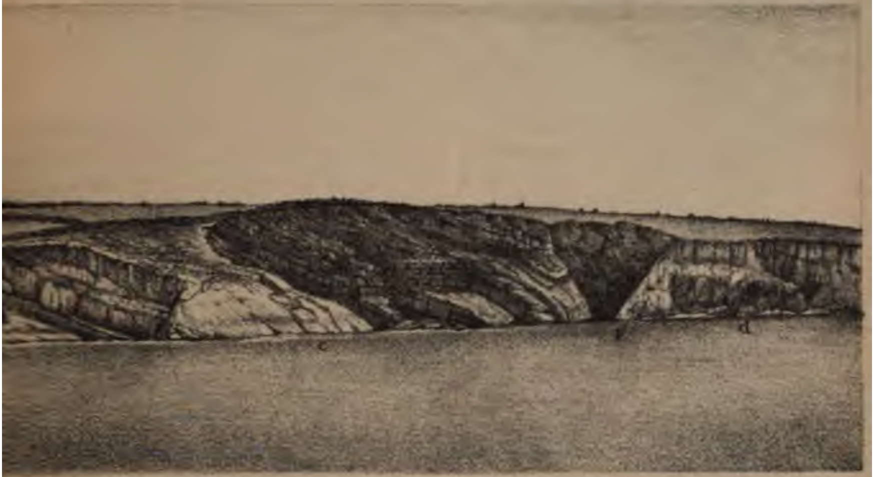

FIG. 3. EAST SIDE OF CAERBWDDY HARBOUR

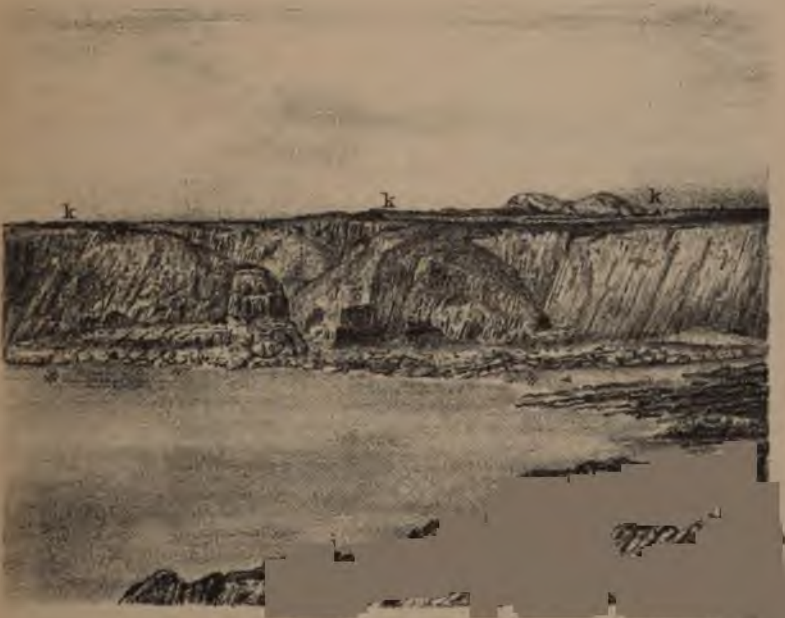

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FIG. 4. NORTH COAST OF WHITESAND BAY

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ASTOR, LENOX AND
TILDEN FOUNDATIONS

clearly divisible—at St. David's, where it has been chiefly explored of late years—into three groups. These are called in ascending order by the local names of Caerfai, Solva, and Menevian (*c*, *d*, *e*, in Sections and Plates).

The *Caerfai group* consists chiefly of conglomerates, sandstones, and red, purple, and green slates and shales. Remains of animal life are found throughout. The most important of these were discovered by me, in 1868, in red slates, near the base, and consist of a *Lingulella*, *Discina*, *Leperditia*, a doubtful head of a trilobite, and abundant traces of annelids.

Beds of the same age are also found in the Harlech Mountains. The great slate quarries of Llanberis, Bethesda, and other places in Caernarvonshire, are also on this horizon. Though the basal beds are not exposed in the Longmynd area, it is probable also that some belonging to this group occur there. There is a strong general resemblance between the beds of this group in each of the areas, but as they were at first shore-deposits around a subsiding land-area, some differences in appearance and in thickness must necessarily occur. The great conglomerates which rest on the Eozoic rocks along the north-west coast of Scotland, are supposed to be of Lower Cambrian age, and may possibly be to some extent contemporaneous deposits with the beds of this lower group at St. David's. This group may be conveniently divided into three parts as under:—

CAERFAI GROUP.	Upper, 1000 ft.	Purple Sandstones with *Annelids*, &c.
	Middle, 50 ft.	Red Shales and Schists, with *Leperditia cambrensis*, *Lingulella primæva*, *Discina caerfaiensis*, &c.
	Lower, 520 ft.	Conglomerates and Greenish Flaggy Sandstones with *Annelids*, *Fucoids*, &c.

Solva group.—Like the underlying Caerfai group, this may be also divided into three parts. The lowest beds are yellowish sandstones, with some conglomerates, and these are succeeded by grey flags. The latter contain an important fauna which I discovered in 1867. It consists of several trilobites, including the genera *Plutonia*, *Paradoxides*, *Conocoryphe*, and *Microdiscus*, also a *Lingulella*, *Theca*, and *Protospongia*. The species are all restricted to this horizon, and the genus *Plutonia* has not been discovered elsewhere as yet. The middle portion of this group consists of red, purple, and grey grits, sandstones, and slates; it is of great thickness, and probably contains several fossiliferous horizons. At present, though fragments have been found in several different beds, the only position in which they appear to occur in any abundance, is towards the upper part of the series; here are found new species of *Paradoxides* and *Conocoryphe*, as well as fragments of several other fossils. Numerous markings are seen also on the surfaces of these and the underlying beds, similar to those described by Dr. Torell from Scandinavia, under the name of *Eophyton*. These were supposed by him to be land plants. Besides these numerous large so-called fucoidal markings are also frequently found. Whether any of these can be safely attributed to land or marine plants, must still be a matter of doubt, as no indications of true structure have been found in them. The upper beds of this group are grey grits and flags, and these also contain a special fauna. There can be no doubt that the Solva group represents the main portion of the Harlech-grit series as known in Merionethshire, and also probably of the Longmynd rocks. That there are some beds in those areas which may be considered contemporaneous with the Caerfai group, is, as I have already stated, probable; but I believe that the St. David's area was depressed at an earlier epoch than either of those, and therefore that it probably contains a series unrepresented there. I am inclined to think, however, that the lower beds of green grits and slates at Llanberis are nearly on the horizon of the Lower Caerfai rocks at St. David's. The rocks at Bray Head, in Ireland, appear to be more nearly contemporaneous with the Solva group than with the earlier beds. The St. David's fossils have not as yet been discovered in any of the other areas. Annelids and a doubtful trilobite, *Palæopyge*, were, however, found years ago by Mr. Salter in the Longmynd rocks; and annelids and the curious fossil, Oldhamia, have been found in the Bray-Head rocks.

SOLVA GROUP.	Upper, 150 ft.	Grey Rocks, with *Paradoxides aurora*.
	Middle, 1500 ft.	Grey, purple, and red Rocks, with *Paradoxides solvensis*, *Conocoryphe solvensis*, &c.
	Lower, 150 ft.	Yellowish Grits, Sandstones, and Flags with *Paradoxides Harknessii*, *Plutonia Sedgwickii*, and also *Eophyton*, large Fucoids, &c.

Menevian group.—This name was given by the late Mr. Salter and myself in 1865, to a series of beds found to contain a very important fauna new to this country at St. David's. Though there is a gradual passage from the beds of the Solva group into these (as shown in Sect. 1, p. 308, and in Pls. VII. and VIII.), in general appearance the rocks differ considerably from those in the other Lower Cambrian groups. This may be due to the combined influence of deeper water, and the presence of a greater abundance of animal and vegetable life; the finer material to the former, and the dark colour to carbon and other substances derived from the latter. Though not of great thickness, the group is yet divisible into three well-marked zones, with distinct species in each. The genus *Paradoxides*, of which so many species occur in the Lower Cambrian rocks, does not in this country reach into higher beds than this group; and by it as well as by several other forms (*Anopolenus*, &c.) the Lower Cambrian is palæontologically well marked off from the Upper Cambrian. There is also an indication of some slight physical change at the close of the Menevian, in the sudden appearance of thick grit beds upon very fine muddy deposits. This is partially shown in the view (Pl. VII.) taken of the east side of Porth-y-rhaw, the place where the group was first made out. Whether this change had anything to do with the disappearance of *Paradoxides* and its allied genera or not, is difficult to make out. It was, at any rate, sufficiently important to have produced identical results in North Wales at the same time, for the upper beds are there, as in South Wales, capped by these massive sandstone beds. This group is everywhere distinct from, and should not be included in, the so-called Lower Lingula flags.* The fauna belonging to this group consists of twenty-three genera, including fifty-two species, and nearly all the species are restricted to it; the range of many is limited to a few beds. This group has been discovered at several places in Merionethshire, and contains there most of the characteristic fossils found by us at St. David's. It is there seen to rest on the well-known Harlech grits, and to be succeeded by Lower Lingula flags.

MENEVIAN GROUP.	Upper, 100 ft.	Sandstones and Shales, with *Orthis Hicksii*, &c.
	Middle, 350 ft.	Flags and Slates, with *Paradoxides Davidis*, &c.
	Lower, 300 ft.	Grey Flags, with *Paradoxides Hicksii*, &c.

The views, Pls. VII., and VIII., figs. 1–3, show tolerably well the succession, and some of the chief sections of the Lower Cambrian rocks on the north shore of St. Bride's Bay, near St. David's.

The *Upper Cambrian* consists of four groups. The three lower ones were carefully described by the late Mr. Belt in 1867,† and named by him, in ascending order, Maentwrog, Ffestiniog, and Dolgelly groups (*f*, *g*, *h*, in sections and plates).

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* It was by mistake that Mr. Etheridge, in the admirable address already referred to, included *Paradoxides* and some other Menevian genera in the Lower and Upper Lingula flag faunas.

† *Geol. Mag.* 1867 and 1868.

These had been partially described previously by Sedgwick and Salter, as Lower, Middle, and Upper Lingula flags. The fourth, or highest, group, was named by Sedgwick, many years ago, 'Tremadoc,' and this name is still retained for that group.

Maentwrog group (Lower Lingula flags).—The lowest beds in this group are described by Mr. Belt as 'grey and yellowish grey, fine-grained pyritic flags, with hard felspathic bands and rusty partings.' Alternations of more arenaceous and gritty beds are not unfrequent, and beds of yellow-grey shale also occur; these are followed by bluish-grey slates and flags. The middle and upper beds also are chiefly flags and slates. At St. David's, the lower beds are thin, ribbony-looking, and much contorted; these are succeeded by dark iron-stained slates and bluish flags. The genus *Olenus* is the characteristic fossil in this group, and it and the Phyllopod crustacean *Hymenocaris* occur here for the first time. The group is divided into upper and lower series, as under:—

MAENTWROG GROUP.	Upper, 1800 ft.	Slates and Flags, with *Olenus truncatus* and *Olenus cataractes*, &c.
	Lower, 700 ft.	Sandy and Slaty Beds, with *Olenus gibbosus*, *Agnostus pisiformis*, &c.

Ffestiniog group (Middle Lingula flags).—This is also divided into upper and lower portions. The lower consists of a series of slightly arenaceous and micaceous grey flags; these are succeeded by thick beds of yellowish-grey arenaceous flags containing hard felspathic layers. The beds in this group are usually easily recognizable, because of the thin alternations of hard and soft layers, and by their peculiar weathering.

Lingulella Davisii and *Hymenocaris vermicauda* are the chief fossils in the lower beds. The upper beds are chiefly blue-grey flags, and contain, besides the above-mentioned fossils, a *Conocoryphe* and a *Bellerophon*. The whole group is very barren of animal remains, and appears to have been deposited in shallow water. The well-known fossil, *Cruziana*, which is, I believe, an Alga, occurs abundantly near Bangor and in other areas in this group; and a large species of *Buthotrephis* was found in it by the late Mr. Belt.

FFESTINIOG GROUP.	Upper, 50 ft.	Bluish-grey Flags, with *Conocoryphe bucephala* and *Bellerophon cambrensis*, &c.
	Lower, 2000 ft.	Arenaceous and Micaceous Yellowish-grey Flags, with *Lingulella Davisii*, *Hymenocaris vermicauda*, *Cruziana*, &c.

Dolgelly group (Upper Lingula flags).—This group consists mainly of blue and black slates. It was evidently deposited in a tolerably quiet sea, and contains a rich fauna. The beds are well exposed in the Mawddach Valley, and about Portmadoc in North Wales. The so-called Malvern black shales also belong to this group. At St. David's, fine grey shales chiefly occur at this horizon. The Olenoid forms, *Parabolina*, *Peltura*, and *Sphærophthalmus*, characterize this group.

DOLGELLY GROUP.	Upper, 300 ft.	Soft Black Slates, with *Peltura*, *Sphærophthalmus*, &c.
	Lower, 300 ft.	Hard Blue Slates, with *Parabolina*, &c.

Tremadoc group.—This group consists mainly of dark earthy flags, flaggy sandstones, and iron-stained slates. It was carefully examined many years ago in North Wales, by Sedgwick, Salter, and Homfray, and shown to contain a very important fauna. Up to the year 1866, it had only been recognized in North Wales; but in that year I was able to announce the discovery at St. David's of a large series of fossils, more nearly allied to those in this group than to any others known. It has since been found in Shropshire by Dr. Callaway. About sixty species have now been discovered altogether, and nearly all are peculiar to the group. Many genera, and several orders, appear here for the first time in the succession. The Lamellibranchs, Crinoids, Asteroids, and Cephalopods, are not known to occur at a lower horizon, and several of these, as yet, have only been found at St. David's, in these rocks.

TREMADOC GROUP.	Upper, 800 ft.	Iron-stained Flags and Slates, with *Asaphus Homfrayi*, *Angelinia*, &c.
	Lower, 200 ft.	Dark Earthy Flags and Flaggy Sandstones, with *Neseuretus*, *Niobe*, &c.

2. *Ordovian* (*Lower Silurian*).

The name 'Ordovian,' has been given to this formation by Prof. Lapworth, who has paid great attention to its fossils, especially to the Graptolites, and these somewhat specially characterize the groups in the formation. I adopt this name now in preference to that of Lower Silurian, as less likely to lead to confusion, and as being in many respects an appropriate one. It consists of four well-marked groups, each with a distinct and important fauna. Three of these have been for a well known, but the fourth, Llanvirn group, is now introduced for the first time, though its position has been partially defined in previous papers.[*] The groups are named, in ascending order, Arenig, Llanvirn, Llandeilo, and Bala.

Arenig group.—This name was first given by Prof. Sedgwick to a group of rocks well developed in the Arenig district in North Wales. For many years, however, it yielded but few fossils, and its importance was scarcely suspected until after the discovery in it, at St. David's, of a very rich fauna. In a former paper I divided the group into lower, middle, and upper parts. I have since found that the upper, as there defined, is so distinct in its fauna from the underlying or middle part, and indeed at present so little known out of the neighbourhood of St. David's, that I have, at the suggestion of Prof. Lapworth, given it a local name, and will therefore describe it as a distinct group. The Arenig proper will, therefore, now be divided into two parts, upper and lower, the former being the portion previously described as the middle part. The group consists almost entirely of black slates, with, however, a few beds of flaggy sandstones, and in North Wales with some grits. Graptolites, which appear for the first time in the underlying Tremadoc rocks,[†] occur in this group in great abundance; the trilobites, also, are altogether unlike those in the underlying rocks. The evidence, therefore, of a palæontological break between the Cambrian and Ordovician, is tolerably clear, though stratigraphically it is not seen. The so-called 'Skiddaw slates' belong chiefly to the upper portion of this group. The graptolites hitherto collected in the lower portion are chiefly *Dichograpti* and *Clonograpti*; in the upper, the genera *Tetragraptus* and *Didymograptus*.

Arenig Group.	Upper.	Slates, Flags, and Sandstones, with *Æglina*, *Calymene*, &c.
	Lower.	Fine Black Slates and Shales, with *Ogygia*, *Trinucleus*, &c.

The view, Pl. VIII., fig. 4, shows the Arenig rocks at Whitesand Bay. A few beds of the Tremadoc group are also seen, but most of the beds of this group have been here cut off by a fault.

Llanvirn group.—As stated above, this group was described by me formerly as a portion of the Arenig (its position is seen in Sect. 2, p. 308). It consists of a thick series of dark slates and shales, with contemporaneous beds of volcanic tuff. It has an average thickness, as now defined, of about 2000 feet, and contains a distinct and important fauna. Most of the species are new, and amongst the trilobites is one genus (*Placoparia*) not elsewhere found in Britain. The fauna, which was worked out by me from the beds at Llanvirn, St. David's, in 1874, is very rich in trilobites; and several genera appear here for the first time in the succession, as *Illænus*, *Illænopsis*, *Barrandea*, *Phacops*, *Placoparia*, and *Acidaspis*. The fauna also contains many graptolites, chiefly of the genera *Diplograptus* and *Didymograptus*, and there are also large Cephalopods, Gasteropods, Brachiopods, and Lamellibranchs. Beds belonging to this group have been explored by Mr. Marr near Caernarvon; they are probably to be found also near Shelve, in Shropshire. The lower portion of the so-called Llandeilo at Abereiddy Bay belongs rather to this group than to the typical Llandeilo, and is here included in it. *Didymograptus Murchisonii* is supposed by Prof. Lapworth to be characteristic chiefly of these beds.

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[*] Hicks, *Quar. Jour. Geol. Soc.* May 1875.

[†] Found by Dr. Callaway in Shropshire, and also by Mr. Homfray near loc.

Llanvirn Group.	Upper.	Fine Black Slates interstratified with Beds of Tuff containing *Didymograptus Murchisonii*, &c.
	Lower.	Dark-grey Flags and Slates, with *Placoparia*, &c.

Llandeilo group.—In the typical area (Llandeilo), Sir R. Murchison described the rocks belonging to this group in ascending order, as dark schists and shales with sandstone courses, followed by calcareous grits and pebble beds, and succeeded by schists in which *Asaphus tyrannus* is conspicuous; upon these occur calcareous, dark-coloured, finely laminated flagstones and schists. This group as it occurs in Pembrokeshire, after excluding the lower beds which I propose now to place in the Llanvirn group, may be divided into two parts; the lower consisting of black calcareous shales and flags, followed by tolerably compact limestone; and the upper portion of black slates, flags, and flaggy sandstones. The beds are well exposed on the north shore of Abereiddy Bay, near St. David's (see Sect. 2, p. 308), and are there highly fossiliferous, *Ogygia Buchii*, *Calymene duplicata*, *Cheirurus Sedgwickii*, *Trinucleus fimbriatus*, occurring in abundance. The Glenkiln slates of Scotland are supposed by Lapworth to be the equivalents of the upper beds of this group.

LLANDEILO GROUP.	Upper.	Black Slates, Flags, and Flaggy Sandstones, with *Ogygia Buchii*, &c.
	Lower.	Calcareous Shales and Flags, &c., with *Asaphus tyrannus*, &c.

Bala group.—The beds of this group are particularly well developed in the neighbourhood of Bala, N. Wales, therefore the name suggested by Sedgwick is peculiarly appropriate. The rocks have also been called by other authors by the name Caradoc, from the Caradoc mountain range in Shropshire, where they are also exposed. The group consists of sandstones, shales, and flags, alternating with calcareous bands and contemporaneous volcanic ash. It attains to a great thickness, but varies considerably in different areas in consequence of the presence of so much volcanic material. Of late years but little work has been done in this group in Wales, but in Scotland the researches of Prof. Lapworth have added considerably to our knowledge of the fauna. The fauna of the Bala group is an exceedingly rich one, especially in trilobites. Graptolites also occur in abundance, chiefly Diplograptidæ and Dicranograptidæ. Prof. Lapworth calls special attention[*] to the 'total distinction in palæontological features between the graptolite faunas of the Bala and Arenig' groups. 'In the true Bala beds not a single example of the families of the Dichograptidæ or Phyllograptidæ has hitherto been detected. So far as our present information enables us to judge, they appear to have become wholly extinct, and their place is occupied by the very distinct families of the Diplograptidæ and Dicranograptidæ.' It is important also to notice, as bearing on the physical history of this epoch, that the 'mortality in families, genera, and species of Rhabdophora in the Upper Caradoc (Bala) beds,' is very great. And that the palæontological break between this last member of the Ordovian formation and the overlying Silurian, so far as the Rhabdophora are concerned, is almost complete. The Hartfell shales of Scotland belong to this horizon.

BALA GROUP.	Upper.	Shales, Flags, and Limestones.
	Lower.	Sandstones and Shales, with Calcareous Bands.

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[*] *Annals and Mag. of Natural History*, series 5, vol. iii.

3. *Silurian* (*Upper Silurian, Murchison*).

Though this name was intended by Murchison to include, perhaps, all the fossiliferous rocks below the Devonian, it has been quite evident for a long time that the restricted meaning in which it is here used is the only way to get rid of much confusion in geological nomenclature. The groups here included in it are, in ascending order, Llandovery, Wenlock, and Ludlow.

Llandovery group.—The name was given to this group by Sir R. Murchison in consequence of the great development of rocks of this age near the town of Llandovery, S. Wales. It is supposed to attain a thickness, there and in Pembrokeshire, of over 2000 feet; whilst it is well known that in some other areas in Wales it thins out to about as many hundred feet. The physical break between this group and the underlying Bala has been frequently referred to by Sedgwick, Ramsay, and others, and there can be no doubt that it is the most important one in the Lower Palæozoic rocks. To a great extent, however, it must be considered to have been produced by local influences. For whilst in the Longmynd and other areas there is ample evidence now to show that there was dry land at the time, there is equally convincing proof that marine conditions continued during the same period in Cardiganshire and Pembrokeshire. In Sect. 3, p. 308, the Lower Llandovery rocks rest conformably upon the Bala beds. The rocks which compose this group vary considerably in different areas, but may be said to consist chiefly of conglomerates, sandstones, shales, and slates. It is usually divided into lower and upper portions,—the latter being also called frequently the 'May-Hill Sandstone series.' The so-called 'Tarannon shales' and 'Denbighshire grit and flag series,' are probably on the horizon of the upper members of this group. In the last-mentioned series I have recently discovered the earliest indications of land-plant remains hitherto found in Britain. They are all in a fragmentary condition and must have been carried into their present positions from some neighbouring lands by floods. These beds have yielded to Prof. Lapworth, in Scotland, a rich fauna of Graptolites, the prevailing family in the lower beds being the Diplograptidæ, whilst in the upper beds the Monograptidæ are dominant.

LLANDOVERY GROUP.	Upper.	Conglomerates, Sandstones, Shales, and Slates.
	Lower.	Conglomerates, Sandstones, and Shales.

Wenlock Group.—This group has a considerable thic and is usually divided into an upper series, under the name of 'Wenlock limestone and shale,' and a lower by the name of 'Woolhope beds.' In North Wales the lower beds rest conformably on the Denbighshire grit and flag series. The Woolhope limestone is supposed to be only locally developed. The fauna of the group consists mainly of Crinoids and Corals; but Brachiopods occur also in great abundance, and numerous new species have been lately added to the fauna by the researches of Mr. G. Maw and Mr. Davidson. Mr. Maw estimates the thickness of the group in Shropshire at over 2500 feet. As previously stated, I exclude the typical so-called Denbighshire grit and slate series from the group, believing that those beds are for the most part on a lower horizon than any rocks usually included in this group in Shropshire.

WENLOCK GROUP.	Upper.	Shale and Limestone.
	Lower.	Shale, Limestone, and Flaggy Beds.

Ludlow Group.—This group in Shropshire attains a thickness of from 1400 to 1800 feet. It consists mainly of dark grey argillaceous shales with calcareous concretions, and limestone. It is divisible, however, into two portions. The upper consisting of light-coloured grits and shales, and the lower of the 'Aymestry Limestone series.' The fauna of this group is important from its including the first indications of vertebrate life as fish remains. Until the discovery by me lately of the land-plant remains in the Denbighshire grit series; it was also supposed that the first evidences of a terrestrial flora occurred in these rocks. The fauna of this group for the most part is highly Silurian in type, but the topmost beds appear lithologically and palæontologically to be passage-beds connecting the Silurian and Devonian formations.

LUDLOW GROUP.	Upper.	Shales, Flaggy Sandstones, and Grits.
	Lower.	Hard Flaggy Shales, with Bands of impure Limestone.

TABLE OF BRITISH LOWER PALÆOZOIC STRATA (1881).

				PETROLOGICAL CHARACTERS.	THICKNESS OF STRATA.	CHARACTERISTIC TYPES AND ORDER OF APPEARANCE OF LIFE.	LOCALITIES WHERE EXPOSED.
SILURIAN (SEDGWICK).	UPPER SILURIAN (MURCHISON).	SILURIAN.	LUDLOW GROUP	Grits, Sandstones, Shales, and Limestone	Feet. 1800	Pisces	Ludlow, Ledbury, Downton, Kingston, Lesmahago, Whitcliffe, Malvern, Longhope, Aymestry, View Edge, &c.
			WENLOCK GROUP	Shales and Limestone	2500		Wenlock Edge, Dudley, May Hill, Malvern, Llangollen, &c.
			LLANDOVERY GROUP	Conglomerates, Sandstones, Slates, and Shales	160 to 2500	Plantæ (land plants)	Llandovery, Haverfordwest, May Hill, Corwen, Tarannon, Birkhill, Girvan, &c.
UPPER CAMBRIAN.	LOWER SILURIAN.	ORDOVIAN.	BALA GROUP	Sandstones, Flags, Shales, and Limestone	4000 to 12,000		Bala, Caradoc Ridge, Horderly, Norbury, Snowdon, Haverfordwest, Wexford, Kildare, Hartfell.
			LLANDEILO GROUP	Calcareous Shales, Flags, and Sandstones	3000	Actinozoa	Dumfriesshire, Llandeilo, Builth, Abereiddy Bay, &c.
			LLANVIRN GROUP	Grey Flags and Black Slates	2000		Llanvirn and Coast of Abereiddy Bay, Ramsey Island, Shelve, &c.
			ARENIG GROUP	Slates, Flags, and Sandstones	2500	Gasteropoda Echinodermata (*Crinoidea*, *Asteroidea*)	Arenig, Shelve, Ramsey Island and and Whitesand Bay (St. David's), Skiddaw (Cumberland).
MIDDLE CAMBRIAN.		UPPER. CAMBRIAN.	TREMADOC GROUP	Dark Slates and Flaggy Sandstones	1000	Hydrozoa (*Graptolites*). Lamellibranchiata and Cephalopoda	Portmadoc, Ramsey Island and Whitesand Bay (St. David's), Shineton (Shropshire).
			DOLGELLY GROUP	Soft Black Slates and Shales	600	Bryozoa (*Dictyonema*)	Portmadoc, Dolgelly, Malvern, Whitesand Bay, &c.
			FFESTINIOG GROUP	Grey arenaceous and micaceous Flags	2000	Heteropoda, Plantæ (marine-plants)	Maentwrog, Dolgelly, Malvern, Ramsey Island, Solva.
			MAENTWROG GROUP	Slates, Flags, and Sandstones	2500	Crustacea (*Phyllopoda*)	Maentwrog, Dolgelly, Solva.
ER. BRIAN.	CAMBRIAN.	LOWER CAMBRIAN.	MENEVIAN GROUP	Dark Slates and Flags	750	Echinodermata (*Cystidea*) Pteropoda	St. David's, Solva, Maentwrog, Dolgelly.
			SOLVA GROUP	Purple, Red, and Grey Grits, Flags, and Slates	1800	Crustacea (*Ostracoda*, *Trilobita*)	Solva, St. David's, Harlech Mountains, Longmynd Range, Bray Head, &c.
			CAERFAI GROUP	Purple, Green, and Red Sandstones and Slates, Conglomerates.	1600 to 4000	Brachiopoda, Protozoa, Annelida, Plantæ?	St. David's, Whitesand Bay, Bangor, Llanberis, &c.

EXPLANATION OF PLATES VII. AND VIII.

Views from Photographs taken by E. H. Griffiths, Esq., M.A., F.G.S., and H. T. Hall, Esq., B.A.

Plate VII.

Fig. 1. View of the East side of Porth-y-rhaw to Cradle Rock, showing junction of Menevian and Maentwrog groups.

Fig. 2. View of the Coast from Porth-clais to Caerfai, showing Caerfai and Solva groups.

Plate VIII

Fig. 3. View of the East side of Caerbwddy Harbour, showing fault near junction of Caerfai and Solva groups.

Fig. 4. View of the North coast of Whitesand Bay, showing the Arenig rocks.

The small letters have the same signification as in the woodcut sections.

** Indicate the chief fossiliferous ocalities.

† Indicates intrusive rock.

F Fault.

SECTIONS ACROSS EOZOIC AND OLDER PAL

Horizontal Scale about 1 inch to a mi

FIG. 1.—Section across St. I

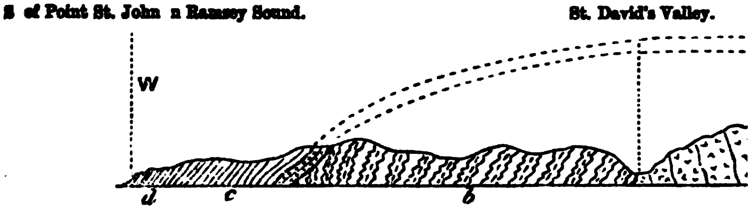


FIG. 2.—Section from the Coast near S

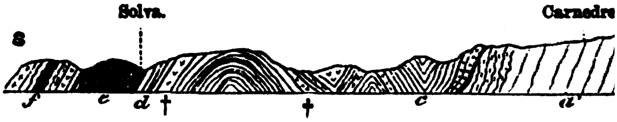
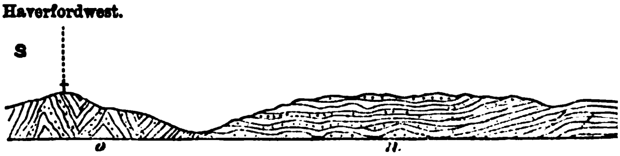


FIG. 3.—Section from Haverfordwest t



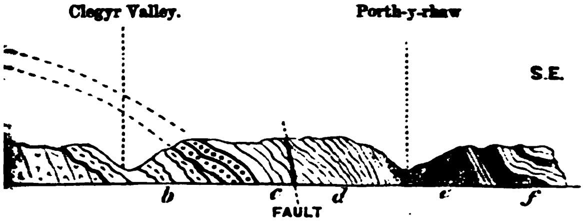
o. Llandovery Group
n. Bala ,,
m. Llandeilo ,,
l. Llanvirn ,,
k. Arenig ,,
i. Tremadoc ,,
h. Dolgelly ,,
g. Ffestiniog ,,
f. Maentwrog ,,
e. Menevian ,,
d. Solva ,,
c. Caerfai ,,

PALÆOZOIC
(Lowest Groups).

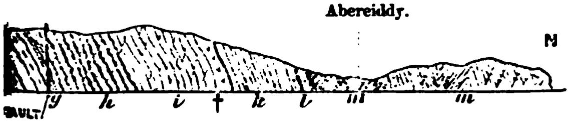
IN PEMBROKESHIRE, SOUTH

ale about 1 inch to 1000 feet.

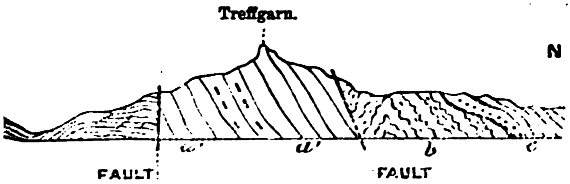
tory, Pembrokeshire.



st N. of Llanrian, Pembrokeshire.



Treffgarn Rocks, Pembrokeshire.



b. Pebidian Formation }
a'. Arvonian ,, } Eozoic.
a. Dimetian ,, }
† Igneous Rocks.

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ASTOR, LENOX AND
TILDEN FOUNDATION

ON THE COLOURS OF SPRING FLOWERS.*

By ALFRED W. BENNETT, M.A., B.Sc., F.L.S.

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EVERY one must have noticed the variations in the predominant colour of our wild flowers as the season advances from spring to summer and autumn. In our hedge-banks the pure white of the larger stitchwort and 'Jack-by-the-hedge' gives way to the bright blue of the speedwell, and then to the reddish-purple of the black horehound and the various shades of the mallows. In our meadows the golden-yellow buttercups are gradually replaced by the pink of the sorrels and ragged robins, and then by the yellow ragwort and purple knapweed. Our river-sides are gay in the early spring with the golden marsh-marigold, in the early summer with the yellow flag, in the later summer with the purple loosestrife. The bright scarlet of the poppies and the pimpernel only appears with the ripening corn. The blue campanulas, the bright-yellow St. John's wort, the purple heather, do not brighten the landscape till the summer is in its prime, when the green or inconspicuous flowers of the hazel, the elm, the oak, and nearly all our timber trees, have long since passed away. I do not know, however, that these facts have ever been tabulated, or any attempt made to reduce them to a general law; the present article is intended as a contribution to this object as far as our early spring flowers are concerned.

Under the title of early spring flowers I include all those named in Hooker's *Student's Flora* as beginning to blossom not later than April, with a very few additions which I think ought also to be included, at all events in our southern counties, viz., *Ranunculus bulbosus*, *Lamium album*, and *Myosotis collina*. As my object is to ascertain the prevalent colour of the spring flora, I have confined the list to common plants, excluding those of less general distribution which might obviously introduce an element of error into the average. For this purpose I have taken as my guide the last edition of the *London Catalogue of British Plants*, and have struck out all which do not bear at least as high a number as 50. Though this mode of limitation is not altogether satisfactory—as plants of wide distribution may nevertheless not be common—it is, I think, the best available. In the limitation of species, I have followed Hooker's *Student's Flora*. The classification of colours, where so many shades are represented, is not easy. I finally decided on arranging them under five heads, viz., (1) white, (2) green, (3) yellow, (4) red and pink, (5) blue and violet. Very slight shades of colour, as in *Anemone nemorosa*, *Cardamine pratensis*, and *Oxalis acetosella*, are neglected. The sweet violet is placed under two heads. Finally, several large natural orders in which the flowers are very inconspicuous are entirely passed over, viz., the Amentiferæ, Juncaceæ, Gramineæ, Cyperaceæ, and Coniferæ.

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* An abstract of this Paper was read at the York Meeting of the *Association.*

The following is the classified list of common early spring flowers thus obtained :—

White.	*Green.*	*Yellow.*		
Anemone nemorosa.	Ribes rubrum.	Ranunculus auricomus.	Sherardia arvensis.	Viola palustris.
Ranunculus aquatilis.	„ nigrum.	„ acris.	Petasites vulgaris.	„ odorata.
Cardamine pratensis.	Callitriche verna.	„ bulbosus.	Vaccinium Myrtillus.	„ hirta.
„ amara.	Smyrnium Olusatrum.	„ Ficaria.	Lamium purpureum.	„ canina.
„ hirsuta.	Adoxa moschatellina.	Caltha palustris.	Orchis mascula.	Vinca minor.
Sisymbrium Alliaria.	Mercurialis perennis.	Ulex europæus.		Myosotis collina.
Erophila verna.	Ulmus montana.	Chrysosplenium alternifolium.		Veronica agrestis.
Capsella bursa-pastoris.	„ campestris.	Tussilago Farfara.		„ Buxbaumii.
Lepidium Smithii.	Arum maculatum.	Senecio vulgaris.		„ hederæfolia.
Teesdalia nudicaulis.		Taraxacum officinale.		Nepeta Glechoma.
Viola odorata.		Primula vulgaris.		Scilla nutans.
Cerastium semidecandrum.		„ veris.		
„ glomeratum.		Narcissus Pseudo-narcissus.		
„ arvense.				
„ triviale.				
Stellaria media.				
„ Holostea.				
Oxalis acetosella.				
Prunus communis.				
Fragaria vesca.				
Potentilla Fragariastrum.				
Saxifraga tridactylites.				
„ granulata.				
Anthriscus sylvestris.				
Bellis perennis.				
Lamium album.				

Out of a total of sixty-four species, there are in this list 26 white, amounting to 40·5 per cent; 9 green, or 14·1 per cent; 13 yellow, or 20·3 per cent; 5 red or pink, or 7·8 per cent; and 11 blue or violet, or 17·4 per cent. I have not been able to prepare a similar list of our common summer and autumn flowers; but even without this there are a few points which strike one at once. Firstly, there is the very great preponderance of white flowers, which is certainly not the case at any other time of the year. Yellow is also greatly in excess as compared with other seasons; and the number of red and pink flowers is extremely small. It is obvious that if the excluded natural orders named above were restored, the plants belonging to them having mostly inconspicuous green or brown flowers, while some have bright yellow anthers, the proportion of red and blue in particular would be greatly diminished. It will be observed that the common cuckoo-pint is reckoned a green flower, from the colour of the spathe which encloses the whole inflorescence.

Before attempting to draw any conclusions from these figures, it may be useful to compare them with those relating to some other spring flora, say that of Switzerland. The difficulties in the way of any exact enumeration are here very great. The best materials at my hand are the two volumes already published of Seboth's *Alpine Plants;* but these include only 200 species selected for a special purpose. Although not entirely satisfactory, such a list may yield some trustworthy results. I have here taken May, instead of April, as the latest early spring month; and have no data from which to exclude any species on account of their rarity. From these volumes is compiled the following list of early spring-flowering Alpine plants:—

Anemone narcissiflora.	Convallaria verticillata.	Ranunculus Thora.	Anemone Halleri.	Thlaspi cepæfolium.
„ alpina.		Trollius europæus.	Thalictrum aquilegiæfolium.	Phyteuma comosum.
„ vernalis.		Draba aizoides.	Silene acaulis.	Myosotis alpestris.
Helleborus niger.		Biscutella lævigata.	Geranium macrorhizum.	Gentiana acaulis.
Arabis alpina.		Viola lutea.	Saxifraga oppositifolia.	„ verna.
Kernera saxatilis.		Orobus luteus.	Valeriana montana.	Pinguicula vulgaris.
Silene alpestris.		Geum montanum.	Erica carnea.	Soldanella alpina.
Mœhringia muscosa.		Aronicum Clusii.	Erinus alpinus.	Globularia cordifolia.
„ Ponæ.		Arnica montana.	Androsace chamæjasme.	
Saxifraga crustata.		Orchis sambucina.	Corthusa Matthioli.	
„ cuneifolia.			Primula villosa.	
„ petræa.			„ farinosa.	
Bellidiastrum Michelii.			„ commutata.	
Pinguicula alpina.				
Androsace chamæjasme.				
Daphne alpina.				
„ Blagayana.				
Narcissus poeticus.				

Out of fifty species in this list (one *Androsace chamæjasme*, being again reckoned twice over among the whites and pinks), 18, or 36 per cent are white; 1, or 2 per cent green; 10, or 20 per cent red or pink; and 8, or 16 per cent blue or violet.

Several points of contrast between these two lists will at once suggest themselves. The very small number of green flowers in the second may no doubt be due partly to the fact that Seboth's work includes a selection only of Alpine flowers suitable for cultivation. But this will hardly account for the other differences; the smaller proportion of white flowers, and especially the very much larger proportion—about three and a half times as many—of red and pink flowers, a fact which will be in accordance with every one's recollection of the early spring flora of Switzerland. Now let us see whether we can arrive at any general conclusions from these data.

In the first place, it must be borne in mind that the two colours white and green stand on a different footing from all the rest, and may be regarded as, more correctly speaking, an indication of the absence of colour. The colour of green petals is not due to a mixture of blue and yellow pigments, but to the presence of chlorophyll, the ordinary green colouring matter of leaves. The bright colours of petals are not usually assumed till immediately before their emergence from the bud; and not a few—as for example those of *Cobæa scandens*, are still green when they first open, acquiring their proper colour only on full exposure to the light and warmth. A white flower again does not owe its colour to a milk-white fluid in the cells of the petals, but to the presence of air. Seeing, therefore, that the bright-coloured fluid pigments of petals are formed only under the influence of a sufficient supply of light and heat, the large proportion of green and white in our early spring flowers is easily accounted for. Then with regard to yellow, I find an exceedingly interesting observation by M. Flahaut* that 'a solid insoluble pigment, the *xanthine* of Frémy and Cloëz, is in the first place to be distinguished from all the soluble colouring matters, blue, yellow, red, and their mixtures, all of which are acted on very readily by reagents, and which are usually formed only in the epidermal cells.' This xanthine Frémy states to occur always in 'the form of clearly defined grains, occasionally in the epidermal, much more often in the deeper-lying cells, slowly soluble in alcohol and potassa. It is in all probability a modification of chlorophyll.' The following is a list of the plants in which he has detected it:—*Ranunculus*, *Primula*, *Cheiranthus*, *Galeobdolon luteum*, *Doronicum plantagineum*, *Alyssum saxatile*, *Cypripedium Calceolus*, *Azalea chinensis*, *Uvularia*

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* *Bull. Soc. Bot. France*, xxvi. (1879), p. 249.

grandiflora, Eranthis hyemalis, Forsythia viridissima, Tussilago Farfara.

It is worth noting that these are without exception early, and some of them very early, spring-flowering plants. The colours, therefore, which pre-eminently distinguish our summer and autumn flora, the reds, pinks, blues, and some yellows (not due to xanthine, but to a soluble yellow pigment), are caused by the presence of substances which require both a strong light and a high temperature for their production, and Professor Batalin has shown this to be especially the case with the red colouring substance.* That the same species of flower frequently assumes a more intense colour with increasing altitude in the Alps is a matter of ordinary notice, confirmed by the exact observations of M. Bonnier,† who states that this change is due to an actual increase in the amount of colouring matter in the cells. The difference already pointed out between the prevailing colours of the spring flora in England and in Switzerland, seems to me to be due to the same cause. Owing partly to the spring being a month later, partly to the more southern latitude, and consequent greater elevation of the sun, partly to the clearer air of a high altitude, the light which opens the earliest spring flowers is much stronger in Switzerland than in England, causing the appearance of those brilliant roses and pinks of the Silenes, Ericas, and Primulas, and blues of the Gentianas, Soldanellas, and Phyteumas, with which we have, with the exception of our blue-bells, scarcely anything to compare in our spring flora. In the list given above, the most striking feature of the early spring flora of Switzerland is seen to be the very large ingredient of red and pink: but I believe a more complete analysis would show an almost equal preponderance of blue.

I have not in this paper touched on the interesting subject of the adaptation of the various colours of flowers to fertilization by insect agency, about which much has been, and very much might be, written. As Hermann Müller points out in his most recent publication,‡ changes in the colour or form of flowers which are serviceable to them for purposes of fertilization, can only be the result of external physical causes, and must be perpetuated by natural selection acting on heredity. This writer, who has made the subject specially his own, fully confirms the statement of the greater brightness of colour of the flora of the Alps as compared with that of the plains, a result not only of the occurrence of brighter-flowered species, but also of the greater intensity of colour in the same species. This he attributes to the greater transparency of the mountain air, and consequent more intense light, an explanation which is confirmed by the experiments of Siemens with the electric light.* The observations of Müller with regard to the prevalent colours of Alpine flowers are completely in accord with those stated above, viz., the comparative scarcity of white, and the remarkable prevalence of red and blue flowers; he further states that those flowers only are red or blue which are visited chiefly or exclusively by bees and 'hover-flies' (Syrphidæ). It would be interesting to compare this fact with the time of year at which these groups of insects are most abundant.

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* *Acta hort. Petrop.* VI. ii. p. 279.

† *Bull. Soc. Bot. France*, xxvii. (1880), p. 103.

‡ *Alpenblumen; ihre Befruchtung durch Insekten und ihre Anpassungen an dieselben. Leipzig*, 1881.

The conclusions arrived at in this paper are somewhat at variance with those of Mr. Buchan,† who states that the blues, on the average, flower considerably the earliest; then, in order, the whites, purples, and, lastly, the yellows and reds. It is possible that the discrepancy may arise from Mr. Buchan having based his result on the entire English flora, while I have taken only the commonest flowers.

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* See *Nature*, 1880, vol. xxi. No. 535.

† *Proceedings of Edinburgh Botanical Society*, 1876.

THE RETREAT OF THE EUROPEAN GLACIERS.

By Professor C. DUFOUR.[*]

1870, when M. F. A. Forel and myself were on the Rhone glacier, we mapped the front of the glacier. I have since eatedly communicated to the Society the results of fresh surements which have been made there, and which, year by r, have shown that this glacier was undergoing a considere diminution, so that, in 1879, it had gone beyond all vious limits, so far as the memory of the inhabitants of country could go back. This retreat, which commenced ut 1855 or 1856, is not peculiar to the Rhone glacier; it is general phenomenon throughout the chain of the Alps, ough it did not commence everywhere at the same time, e glaciers were advancing when others were decreasing. t at present it may be said that the retrograde movement become the rule in all the Alpine regions.

In 1878, at the Scientific Congress in Paris, I had the ortunity of conversing on this subject with several French *ants*, and learned from them that the glaciers of the renees were in the same case; all of them had diminished, some had actually disappeared. It then became an intering point to ascertain whether the other European glaciers, se of the Caucasus and of Scandinavia, presented the same enomenon. With this purpose in view, I applied, with ard to the former, to M. Wild, the director of the Central ysical Observatory of Russia, and with regard to the latter, a Swede, M. Nyström. These two gentlemen were kind ugh to obtain the information that I asked for, and from ir investigations it appeared that these groups of glaciers d diminished in the same way as those of the Alps and renees. In the Caucasus the retreat commenced, as in the case of the Rhone glacier, in 1855 or 1856. In Scandinavia, it appeared to have varied from one glacier to another, but it has now become general. M. Nyström was so kind as to consult the illustrious Swedish traveller, M. Nordenskiöld, upon this subject, who told him that the glaciers of Spitzbergen had undergone a similar diminution during the last few years.

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[*] From the *Bulletin de la Société Vaudoise des Sciences Naturelles*, Serie ol. xvii. pp. 422–425.

In August, 1880, I laid a communication on this subject before the Scientific Congress at Rheims. In the discussion which arose upon the matter, several people cited facts in support of those which I had pointed out; and one of those who took part in the debate, and who had been several times to Greenland, had observed that the glaciers of that country had also retreated considerably.

It would be interesting to know what has been the condition of the Asiatic and American glaciers, and of those of the southern hemisphere, during the same periods. But in any case the retreat of the four great European groups of glaciers, those of the Pyrenees, the Alps, the Caucasus, and Scandinavia, as well as those of Greenland and Spitzbergen, is a fact of great importance in physical geography, since it involves all those of the northern hemisphere over an extent of 100° of longitude. It is well worth while to pay attention to it, and to watch the progress of the phenomenon.

It is perhaps difficult at the moment to indicate the cause of this retreat, for, from the meteorological point of view, the last few years have not been very different from those which preceded them. Moreover, the advance or the retreat of a glacier depends upon several factors; first of all, upon the heat and humidity of the summer, and then upon the frequency and intensity of warm winds. As regards heat and wind, the consequences are indirect, but they are less so with respect to humidity. In fact, as M. Forel and I have shown by experiments made in 1870 upon the Rhone glacier, the aqueous vapour of the atmosphere condenses upon the ice, as it condenses in winter upon the glass windows of our rooms, and this water of condensation considerably augments the volume of the water that issues from the glacier; now this condensation is accompanied by an evolution of latent heat, which contributes greatly to the melting of the ice. But the extent of a glacier depends not only upon the forces which tend to destroy it, but also upon those which tend to form it, that is to say, upon the accumulation of snow in the basin of reception which is the origin of the glacier. These snows, which by degrees become converted into ice, are in considerable quantities, and represent the falls which have taken place during several years. This mass moves slowly, and it is not until the lapse of a great many years that the ice, us formed, arrives at the bottom of the glacier, where it melts. ll this ice, therefore, represents the sum of the meteorological ctions that have taken place during a very long period of time, erhaps more than a century.

It would, therefore, be a mistake to seek in the last few ears alone the cause of that retreat of the glaciers which we an now demonstrate. This would, no doubt, be the right course the retreat were caused solely by a more rapid melting, but is quite otherwise if this cause ascends to the very origin of he glacier. Now the latter is probably the case, for meteorogical observations do not reveal to us any notable difference etween the last quarter of a century and a preceding period. his is why the investigation of the great retreat of the laciers that we now witness, must not be neglected; it is right o watch and trace it to the end in all those countries where t has been demonstrated; and the cause of this retreat, if we ucceed in ascertaining it, will be an important factor among hose which engage our attention in the study of the physics of he globe.

Now, with regard to most glaciers, it is not difficult to ppreciate the amount of the retreat. It is only necessary o draw a map of the lower extremity, as I have done several imes with M. Forel in the case of the Rhone glacier; and in a uestion of this kind, with an element so variable as a glacier, t is not necessary to determine the position of each point ithin a centimetre or two. Upon the moraine in front of he glacier we have established two fixed points, by means of wo stakes firmly driven into the ground down to the level f its surface; thence, with a small sextant, we determine the osition of the most important points of the front of the lacier, which enables us to map it, and to see readily for each egion of the glacier the amount of the retreat from year to ear.

THE STORAGE OF ELECTRICITY.

By J. MUNRO, C.E.

THE last five years have been marked by an extraordinary development of electrical invention. They have given us the speaking telephone and the microphone, which may now be found working conjointly in transmitting all varieties of human speech by wire in every clime, from London to Honolulu, and from Stockholm to Melbourne. They have given us the duplex and quadruplex modes of sending an ordinary telegram, so that two, and even four messages of entirely different import may be passed through a single overland line or submarine cable simultaneously, without either jostling or obliterating one another. They have given us the electric light to illuminate our streets, factories, and homes with artificial sunshine; and they have given us the means of conveying power by electricity to great distances, so that in the future we may drive our looms and speed our trains by the energy of waterfalls among the hills, and light our beacons by the fury of the waves which break around them. A thousand possibilities of electric labour open on our sight, and in a few minutes we can prophesy what the next fifty years will fulfil.

The application of electricity to lighting and motive purposes which promises so largely for the future, is chiefly due to the recent perfection of the dynamo-electric machine, whereby electricity is generated in a coil of wire rapidly rotated in the magnetic space between the opposed poles of two powerful electro-magnets. Unlike the clumsy and troublesome voltaic battery, it is compact and portable, and yields a steady current so long as the coil is rotated. This current may be conducted by wires to an electric lamp, and there transformed into a splendid light; it may be used instead of a battery-current to transmit telegrams, after the fashion of the great Western Union Telegraph Company of America; or it may be sent through a second dynamo-electric machine so as to set its coil rotating by a reversal of the generating process, and thus perform work like any other engine. Electricity, then, can be produced in large quantities, and conveyed to long distances with the speed of light; but there remains another property which it would be well to have, if ever it is to become of universal service. It should be capable of being stored up, like water in a tank or coal-gas in a holder.

Hitherto electricians have not been quite devoid of apparatus for storing electricity. They had the contrivance known as a 'condenser,' in which two or more sheets of tinfoil, A, B, are separated by an insulating material, C, such as paper soaked in wax-paraffin, or mica. When A is connected to one pole of a voltaic battery and B to the other by the wires WW, the metal plates take in a charge of electricity, after the manner of the Leyden Jar, and will contain it for an indefinite time. To discharge them it is only necessary to connect A to B by a conductor; but this discharge is instantaneous, and therefore quite unsuited for electric lighting, or motive purposes, where a steady and continuous *current* is required. Besides the 'condenser,' there is however another contrivance known as the 'secondary battery,' which takes in its charge by degrees and gives it out again just as gradually; and under the exigencies of modern life, this apparatus has been so far improved within the last few months as to become a practical reservoir for electricity.

The 'secondary battery,' as it is called, originated, first of all, in a discovery made by a French *savant* named Gautherot as far back as 1801, or about a year after Volta's pile, the progenitor of the present voltaic battery, appeared. Gautherot connected wires of gold to the poles of the Volta pile, and when he plunged them in water to decompose it into its constituent gases, oxygen and hydrogen, he noticed that these wires themselves yielded a brief current after the pile itself had been disconnected, and always in a direction opposite to the current of the pile. This effect, which is familiar to students of electricity under the name 'polarization of electrodes,' was remarked still later by a German physicist, Ritter, who fertilized the observation by his genius and thus created the first 'secondary battery.' Ritter devised several batteries for the express purpose of supplying these secondary currents; he tried plates of platinum, silver, and iron in place of the gold wires of Gautherot, and immersed them in solutions of different salts instead of water; but he was wrong in supposing the return current to be due to electricity which had soaked into the plates or intervening fluid. The true explanation was given by Volta, Marianini, and afterwards by Becquerel, who showed that the reaction arose from the oxygen and hydrogen of the decomposed water collecting on the metal plates and changing their electric condition with respect to one another; making them, in short, like the two different metals of a voltaic cell instead of one and the same substance. This explanation was further verified by Grove, who, in 1843, actually constructed a 'gas battery,' in which the positive and negative plates or poles of the combination were both composed of sheet-platinum, but one was surrounded with oxygen gas and the other with hydrogen. On connecting these platinum plates by wire, a current was obtained from them, as in the ordinary voltaic cell.

The liberation of gases which goes on in the secondary battery is well shown in the action of the voltameter, Fig. 1. Here the current from a voltaic battery with zinc and copper plates, Z and C, is passed through a little acidulated water contained in the vessel V, and the dis-parted gases, hydrogen and oxygen, are collected in the inverted tubes, H and O, the hydrogen appearing over the wire connected to the zinc or negative pole of the battery, and the oxygen over the copper or positive pole. In the secondary battery these gases collect on the metal plates which are connected to the poles of the charging battery; and when the latter is removed, the secondary current begins to flow, provided always the circuit is completed by joining the plate with a wire. The charging current flows through the liquid from the copper or positive pole to the zinc or negative pole; but the discharging current flows in the contrary direction, that is to say, from the plate on which hydrogen was deposited to the plate on which oxygen was deposited. Speaking generally, the secondary current flows through the liquid *from the* plate which was connected to the negative pole of the

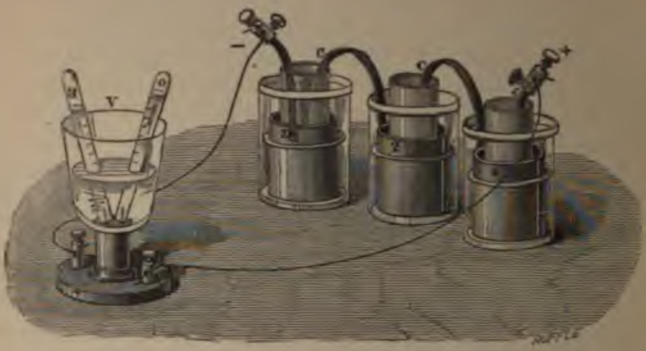

Fig. 1.

arging battery or machine to the plate which was connected the positive pole; and it continues until the separated gases ve all recombined to form water.

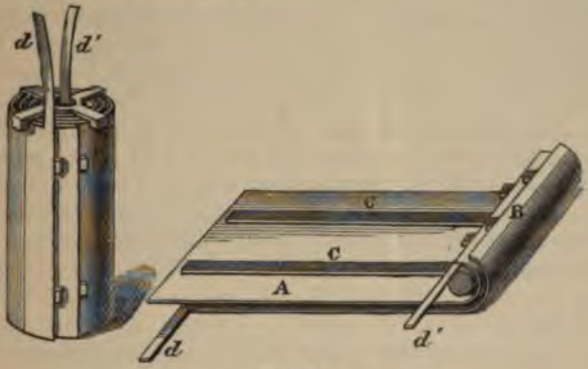

Fig. 2.

In 1859, a great improvement on the secondary battery was ade by M. Gaston Planté, of Paris, who, after trying many fferent metals, selected plates of lead in preference to any her. Lead had been tried by Ritter and abandoned; but in e hands of Planté, and latterly of Faure, it has afforded a actical solution of the problem. Planté takes two sheets of d, A B, Fig. 2, with projections, *d d′*, jutting from them, and

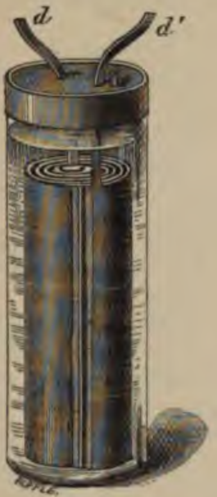

Fig. 3.

after separating them by two strips of thick felt, C C, he rolls them up together and plunges them into a vessel of water acidulated with sulphuric acid. As shown in Fig. 3, this arrangement constitutes a single cell of the Planté battery, the 'electrodes' of which, *d d'*, are brought up through the cover. The large surface of the plates increases the capacity of the cell, and their close proximity to each other diminishes its internal resistance. These cells can be readily charged by a dynamo-electric machine, after the manner sketched in Fig. 4, where the ends of the rotating coil are seen to be connected to the lead plates. Thus charged they will give back the current from the machine any reasonable length of time afterwards with very little loss, and always the discharging current flows *out* of the electrode by which it formerly flowed *in* as a charging current.

Age improves their capacity, for the repeated charging forms a thick film of brown peroxide of lead on the surface of the plate at which the oxygen collects, and the other plate acquires a spongy texture owing to the gases liberated there. During the discharging of the cell, the plate which was peroxidized in charging, becomes again deoxidized, and the current flows until this process is complete.

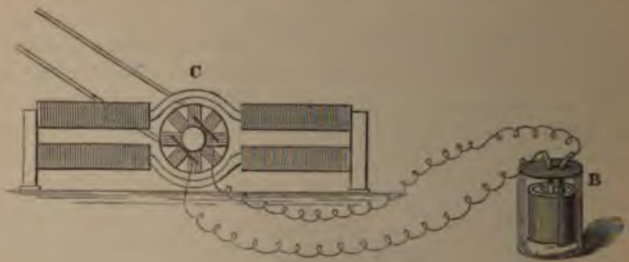

FIG. 4.

Planté's battery has long been used by surgeons as a portable store of electricity for supplying the current necessary to white-heat the fine platinum wire with which they perform the actual cautery. A single cell charged by a pair of Bunsen cells before the surgeon starts on his rounds is sufficient for this purpose. It has also been used to feed a small electric lamp by means of a considerable number of cells coupled together on a portable frame.

Within the last few weeks, however, a further improvement has been made on Planté's secondary battery by M. Camille Faure, who has obviated the waste of time necessary to produce the film of peroxide on the Planté plates by surrounding each late in the first place with a layer of red lead, or minium, into a paste with water, and enclosing it in a sheath of The two lead plates are then laid one over the other, as . 5, and rolled together, then placed in the lead vessel ented in Fig. 6. Thus constructed, the minium of one s itself oxidized by the charging current and the prery formation of peroxide from the lead which took place

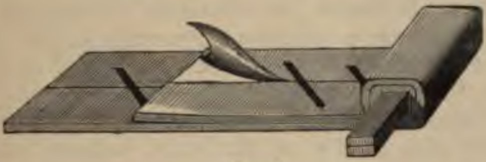

FIG. 5.

nté's original form is avoided, whilst the capacity of the arrangement for electricity is considerably greater than f Planté. How much greater, it is difficult to determine early date. One electrician claims a forty-fold increase of ty, weight for weight, and another puts down the increase y 20 per cent. It is tolerably certain, however, that a battery weighing 165 lbs. is capable of storing a quantity tric energy equivalent to one-horse power of work ex-

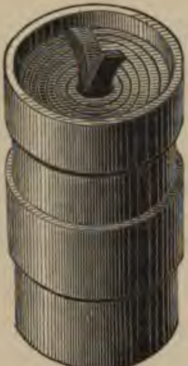

FIG. 6.

l for an hour. Such a battery was recently sent from to Sir William Thomson, at Glasgow; and that dished physicist has published his opinion that an accumueighing fifteen hundredweight will suffice to operate for irs from one charge, doing work at the uniform rate of rse power and with a loss of only 10 per cent of the l *charge through* leakage and so on.

Experiment alone can demonstrate the practical value of the Faure accumulator; but Sir William Thomson thinks that it will not be too heavy to place on board a tram-car or an omnibus, in order to drive the vehicle by its charge in preference to horses. This would be effected by reversing the arrangement shown in Fig. 4, and causing the discharge of the battery, B, to rotate the coil, C; the motion thus produced being, of course, communicated to the wheels of the carriage. In the Siemens electric railway in Berlin, the electricity is conveyed by a wire along the track from a stationary generator at one terminus of the line to the coil of a dynamo-electric machine attached to the locomotive; but there are cases of locomotion in which this plan cannot be followed. Omnibuses, for instance, require to be independent of such a wire, so do boats, balloons, and tricycles. The electricity required to turn the wheels of such free and independent vehicles must therefore be carried with them, either in a voltaic battery, from which it can be got at first hand, or in a secondary battery, giving it at second hand. But in point of lightness and convenience, the secondary battery is far superior to the other, so that we may expect it to be preferred. Recent experiments, by M. Trouvé of Paris, have shown that boats, launches, and velocipedes, may be successfully driven by the electric current; and the prospect is all the better now that M. Faure's secondary battery has come out.

In surgery it has already proved its usefulness in the hands of Prof. George Buchanan, of Glasgow, who excised a nævoid tumour from the fore-tongue of a lad, without losing a drop of blood, through the agency of a wire heated to redness by the current stored in a Faure battery, 9 inches high by 5 inches in diameter. It is in electric lighting, however, that the Faure, or at any rate some other secondary battery, will be most valuable. According to Sir William Thomson, a battery of seven cells, of the above size, is sufficient to keep four or five of the electric lamps of Mr. Swan glowing for at least six hours, with a total luminous effect of 100 candles! It follows that with several of such batteries stationed in a house, and charged with electricity during the day by means of wires from the works where the current is generated, it will be possible to light up the rooms by night, and perform such light operations as turning a coffee-mill or a sewing-machine. The same battery will drive a sewing-machine several hours a-day for a week. In fact, it is not going too far to say that an electric reservoir will be as much a part and parcel of the home in future as a water-cistern or a coal-bin is to-day.

ON THE FORMATION OF THE TAILS OF COMETS.

By M. FAYE.*

IN the *Comptes Rendus* of June 27, I read, not without surprise, a note by M. Flammarion, in which the learned author throws doubt upon the materiality of the tails of comets, and the existence of the repulsive force which produces them, a force the principal characters of which were formerly indicated by me.

It is curious that these denials appear in the same number of the *Comptes Rendus* as the spectroscopic observations of MM. Huggins, Wolf, and Thollon, which show in the analysis of the light of the present comet the super-position of two spectra, evidently due to the presence of material molecules, some reflecting the light of the sun, the others also emitting a light of their own. Moreover, this is what spectrum analysis has proved for all comets, without exception.

The argument upon which M. Flammarion depends recurs to the idea that the comet carries its tail as a sort of brush continuous with itself. He concludes that the extremity of this brush must sweep through space with the frightful velocity of 16,000 leagues per second; and in consequence the above-mentioned brush is not a body, but an appearance, a sort of luminous phantom due to the excitation of the ether situated behind the comet.

This is due to a misunderstanding of one of the greatest scientific problems of our epoch. There is not an astronomer who believes that the tail of a comet is a rigid whole attached to the nucleus: one might as well imagine that the smoke of a steam-boat that started from Havre, and that one sees arriving at New York, has crossed the Atlantic with the vessel. It is two centuries since Newton explained these matters by showing that each section of the tail taken at a given moment was abandoned by the head at an antecedent period—a period more distant in proportion as the section itself is further removed from the nucleus. Each of these sections has followed, in space, an orbit absolutely different from that of the head of the comet; and the tail, in its entirety, is nothing but the envelope of the positions occupied at a given moment by the series of puffs of cometary matter successively emitted and driven off on the preceding days, without there being between them any other connexion than the velocity of translation which they possessed in common at their points of departure.

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* *Read before the* Academy of Sciences of Paris, July 11, 1881.

Calculation applies perfectly to these singular but by no means mysterious phenomena. Bessel furnished their formula, which enables us to determine by the curvature of the tail the intensity of the force that produced it. Quite recently, M. Bredichin, director of the Observatory at Moscow, has obtained from it most interesting results.

As to this force which M. Flammarion denies, although in every comet we see its effects marked in the heavens in gigantic features, it is certain that matters go on as if the Sun was endowed with two actions—one attractive, belonging to its mass, the other repulsive, due to its electric (Olbers), magnetipolar (Bessel), or calorific (Faye) state. We may dispute its essence, or its physical nature, but not its mechanical characters, as I have defined them, because these characters result from the observed facts, namely,—

1. This repulsive force is not proportionate to the masses, like attraction, but to the surfaces. Hence it produces the more marked effects in proportion as the matters subjected to it are less dense.

2. This force is not exerted through all matter, like attraction; it is on the contrary weakened, or even arrested by the interposition of the smallest screen.

3. It is not propagated instantaneously, like attraction, but gradually, like light and heat. It results from this that its action upon a point in motion is not exerted in the same direction as attraction, even though the two forces emanate from the same body.

4. Lastly, this force varies inversely to the square of the distance, like the intensity of light and heat. This is the sole point of resemblance between the two forces which the Sun exerts simultaneously upon all bodies, one which is connected with its mass, and therefore invariable, the other with its physical condition and consequently transitory.

This latter force necessarily affects the planets and their satellites as well as the comets. The first of the four characters *that* I have just indicated will explain how its action upon the planets, which are of incomparably greater density, has hitherto escaped the notice of astronomers. It is a problem reserved for a comparatively near future.

It is exerted also upon our planet at the boundaries of our atmosphere, but its meteorological effects are masked by those of solar radiation, which is much more powerful, and the period of which is exactly the same. I have at least endeavoured to demonstrate its presence around us by the action of incandescent laminæ upon very rarified matter, which I rendered visible by means of electrical currents. In this great difficulties are met with, which will not surprise any one who considers the trouble it has taken to compel even attraction to manifest itself about us between neighbouring bodies.

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In conclusion, I would indicate that the simultaneous existence of several tails, with very different curvatures, is one of the most striking verifications of the characters above assigned to the repulsive force. These multiple tails are not exceptional as was formerly supposed; their presence is a fact which tends to become generalized as comets are observed with very powerful instruments. It is true that the present comet seems to have only one, but this is no doubt due to our being at no great distance from the plane of the orbit, the plane in which all the tails are formed, so that, so far as we are concerned, they are projected one upon the other. It is for the same reason that the tail of the present comet is apparently straight. If instead of seeing it edgewise we saw in face, its natural curvature would strike all eyes.

ATYOIDA POTIMIRIM, A MUD-EATING FRESH-WATER PRAWN.

By Dr. FRITZ MÜLLER.*

THE cleaning of the branchial cavities is performed in some Prawns, such as *Palæmon*, by the first pair of thoracic feet; in the Hermit Crabs, *Porcellunæ*, &c., by the last pair of those feet; and in the true Crabs, by the flagella of the three pairs of jaw-feet. This function is performed in another and quite different manner in a small Prawn found in the river Itajahy, *Atyoida Potimirim*. This little Prawn further presents so many remarkable peculiarities, that some account of it may not be uninteresting even to those readers who do not know much about Crustacea.

The first thing that strikes one is the structure of the hands (claws) or *chelæ*, with which, as in the great majority of the Prawns, the first two pairs of thoracic limbs are armed. The claws, or hands, of Crabs and Lobsters are produced from ordinary walking limbs, by the development of a process of the last joint but one beyond the articulation of the last joint, the last joint and this process being then opposed to each other. We thus have to distinguish the movable finger, the immovable thumb (the process), and the true hand; the latter, as every one knows who has eaten a crab or a lobster, forming the main mass of the claw, and enclosing the powerful muscles which move the finger.

In our *Atyoida*, however, we can hardly speak of a true hand in contradistinction to the thumb; the chela is cleft through its whole length, and the joints of the hand and finger are at the same level. To add to the extraordinary aspect of the claw, the hand is very freely articulated to the lower angle of the deeply-notched fore-arm, and the apical third of each of its divisions is furnished with a dense coating of remarkably long bristles. When the hand is closed, all these bristles meet together to form a long, pointed pencil. They are always seen thus in dead animals, and the hands thus appear quite unfitted for seizing anything, and give no room to suspect what an attractive spectacle they present in the living animal, and how beautifully they are adapted to the food of the animal. This consists of mud, especially the fine mud which settles on aquatic plants and is rich in all sorts of minute living creatures, as well as in decomposing animal and vegetable matters. When the hand opens, the bristles forming the pencil spread out in the same plane, arrange themselves almost perpendicularly to the margins of the fingers, and thus constitute two broad fans, which can take between them a quantity of fine mud particles swept off the leaves of plants; as the hand closes, the bristles also close together again from all sides, and thus press together the food collected into a small morsel, which is conveyed, or rather flung, into the mouth, all the movements being so rapid as scarcely to be followed by the eye. Scarcely is one morsel swallowed, when there comes a second and then a third hand with a new cargo. When the animals are feeding upon the soft mud of the bottom, where they have only to lay about them briskly, the four hands whirl about one over the other with the most restless rapidity. The inner bristles of the fingers are considerably shorter and stiffer than the outer ones; the latter are simple, the former pectinated; they enable the fingers to strip off the adherent slime from delicate roots and stems, which they take between them. It is also very pretty to see the animal lying in wait, if I may use the expression, to seize the fine particles of food floating in the water, whirled towards it by the outer branches of the middle and posterior jaw-feet. The chelæ, opened about at a right angle, hang down from the fore-arm, and all four of them form a transverse series, the second pair of feet, although articulated further back, being longer than the first pair; and from the great breadth that each separate hand acquires from its long bristles being spread out laterally, they keep watch over a very considerable space. From time to time we see one or the other of the chelæ close up and move towards the mouth.

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* *Kosmos*, Band ix. p. 117.

The structure of the organs of the mouth, like that of the hands, is connected with this mode of nutrition, and differs in many respects from that occurring in the Palæmonidæ and other Prawns, as indeed in the other Decapoda generally. The hinder maxillæ, the anterior jaw-feet, and in a less degree also the middle jaw-feet, have a remarkably long, straight inner margin, densely clothed with stiff bristles, some of which are of very peculiar form. It will be easily understood how useful these great folding-doors, with their dense armature of bristles, must be in the reception of morsels made up of fine, loose particles, merely pressed together.

The mandibles, also, are very remarkable. Quite recently it has been put forward, as a distinctive character between the Long-tailed Decapods and the Mysidæ, that 'the right and left mandibles are similar in the Macrura, dissimilar, and often very different, in the Mysidæ.' Even leaving *Atyoida* out of the question, this supposed distinction will not hold good (in the Palæmonidæ, for example, the tubercles of the masticatory processes are quite different to the right and left); but nowhere else among the Macrura have I seen so great a difference between the two mandibles as in our *Atyoida*, where it strikes one at the first glance. I would regard this as an old inherited character rather than as a recent adaptation, more especially seeing that in other respects, also, the mandibles show an ancient form. In those Prawns which have retained to the present day the most complete and original developmental history, the mandibles, at their first appearance in the interior of the third pair of limbs of the Nauplius, show an apical part armed with cutting teeth, a manducatory process furnished with transverse ridges behind this, and between the two a series of bristles; and we find the same three parts in *Atyoida*. Such mandibles are nowadays rare among the Decapoda, but frequent in others of the higher Crustacea, such as the Amphipoda and Cumacea.

The two pairs of feet which follow the chelæ (the third and fourth thoracic limbs) are slender walking limbs, the last joint of which is armed with from six to nine curved, claw-like spines, such as are also met with in other Prawns (*e.g. Hippolyte*), which, like our species, are fond of clinging to plants. The last or fifth pair of limbs is also employed in walking and clinging, and has a few curved spines at the end of the finger; but in addition to these, the lower edge of the finger bears a delicate comb, employed especially in cleansing the abdomen. A systematic cleansing of the abdomen is performed by the animal with great care and deliberation, and occupies several minutes. It commences with the first pair of swimming feet, the four following ones being for the time laid back; when the first pair and the space between the first and second is clean, the second pair comes up, then the third, and so on. Last of all, it comes to the turn of the tail, which has to bend very much forward in order to come within reach of the comb.

Neither the two anterior pairs of limbs, the hands belonging to which, with their long bristles, may occasionally be seen sweeping about the fore part of the body, nor those of the last pair, are adapted to penetrate into the branchial cavities and cleanse them. This is effected by the posterior maxillæ. It is well known that in all Decapoda these maxillæ have externally a large broad plate which is placed as a valve at the outlet of the branchial cavity, and by its movements maintains the respiratory current: in this we distinguish more or less distinctly an anterior part and a posterior section, of which the former must be interpreted as the outer branch, and the latter as the flagellum. When the plate serves only as a valve for regulating the respiratory current, this hinder section is short and truncated, or rounded off at the end, and scarcely extends into the branchial cavity itself: in *Palæmon*, for example, it reaches only to the gill of the outer jaw-foot. In *Atyoida*, on the contrary, this hinder portion is long and narrow, tapering towards the extremity, and here furnished with about a dozen very long flexible bristles: it reaches as far as the last gill but two, which is seated upon the third pair of feet, and its apical bristles to the posterior extremity of the branchial cavity. Thus, as may easily be ascertained by the examination of sufficiently transparent living animals, the whole outer surface of the branchiæ may be swept by it.

Another arrangement may assist in keeping the branchial cavity clear, and this occurs also in many other prawns, such as the very large genus *Hippolyte*. The posterior jaw feet and a variable number of the thoracic feet (in *Atyoida Potimirim* the first three pairs) bear a minute flagellar appendage, which, from its small size, might be regarded as stunted if its peculiar structure did not contradict any such notion. In our *Atyoida*, it may be described as a small sausage-like appendage which originates near the anterior margin of the coxa, and, being directed backward, is applied by its inner surface to the outer surface of the coxa. Its outer surface is beset with about a dozen rather long, straight hairs, arranged in two rows, and its free extremity is furnished with a hook, which probably serves to keep it in position. These flagellar appendages then lie in the entrance to the branchial cavity, in the fissure between the coxæ of the feet and the lower margin of the carapace; they narrow this entrance, and thus, as also by their armature of hairs prevent the entrance of foreign bodies.

But, it will be objected, they are deficient precisely where they would be most necessary, namely, where the water flows most rapidly into the branchial cavity, above the fourth and fifth pairs of feet. Here, however, there is another very peculiar arrangement for the same purpose, and one that, so far
know, has been observed in no other prawn. The abdo
feet of the prawns, as is well known, are (with few excep
of two branches; the branches usually have t
shaped leaves, *the margins* of which are

plumose swimming-bristles. In repose, these swimming feet are thrown forward and laid between the thoracic limbs. Unlike all other prawns that I have seen, in *Atyoida* the outer branch of the first pair of swimming feet is not laid between the last feet of the thorax, but outside over them and the entrance to the branchial cavity, so that all the water entering here is strained through its plumose hairs.[*]

The males of our *Atyoida* are much smaller than the females; I never found the former more than 15 millimetres, while the latter were as much as 25 millimetres long. The better the males are equipped with offensive and defensive weapons, and the more violently they struggle for the possession of their females, the more do they usually exceed the latter in size. This is the case among the prawns of the Itajahy with the male of *Palæmon jamaicensis*, whose chelæ of more than a foot in length almost always bear traces of the battles which it has fought with its rivals. Where weapons are wanting, the female often attains a larger size, which is probably superinduced by the much greater expenditure of material called for by the eggs. To give a second example belonging to the series of the higher Crustacea, I will refer to the Tatuira (*Hippa emerita*), the males of which likewise appear quite dwarfed by the side of the females. Just as in *Atyoida* the males have become or remained unarmed by the adaptation of the chelæ to the purposes of mud-eating, in the *Hippa*, which burrows in the sand, this has come about by the conversion of the apical joints of the legs into broad shovels, only available for digging.

The hands of the male *Atyoidæ* seem to be unfitted not only for contests with their rivals, but also for seizing and holding the females, and it is therefore not surprising that other arrangements have been developed in them, such as we do not find in other prawns whose hands are sufficiently capable of grasping. Thus the terminal spine of the posterior jaw-feet, which is straight in the female, is converted in the male into a curved claw; and on the inner surface of the tibiæ of the third and fourth pairs of feet there is a strong denticulated spine, and opposite to it numerous wartlike tubercles, which, like the spine, are entirely wanting in the female.

There is yet another remarkable difference between the sexes to which I must refer. In the males, the inferior angle of the anterior margin of the carapace is rounded, while in the females it is produced into an acute tooth (Simpson's 'spina pterygostomiana'). Exceptions to this rule are very rare. The armature of the anterior margin of the carapace has hitherto

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[*] From Milne-Edwards' figure of *Caridina typus* (*Hist. Nat. Crusst.* Pl. xxv. *bis*, fig. 4), I conclude that in this respect the nearly allied genus *Cari- na* agrees with *Atyoida*.

not only served as a certain character for species, but it has even been employed for the distinction of genera. Thus, the genus *Leander* has been separated from *Palæmon* solely because the former possesses a 'spina branchiostegiana,' but no 'spina hepatica;' and the latter a 'spina hepatica,' but no 'spina branchiostegiana.' Now, in *Atyoida Potimirim* the presence or absence of the 'spina pterygostomiana' constitutes a simple distinction of sex or age, for all the younger females of less than 12 millimetres long agree with the males in wanting the spine at the lower angle of the carapace. As the males remain much smaller than the females, it seems quite intelligible that many peculiarities of the females, which only make their appearance when the latter have grown to exceed the size of the males, may never arrive at development in the latter. In this way, for example, we may explain the difference in the number of bristles at the extremity of the last segment of the body, or the middle caudal plate (*Telson*) in adult males and females, as this number in general increases with size and age, although it is not always the case that larger animals have more numerous bristles. In eleven young animals, 8–12 millimetres long, which as yet showed no external sexual differences, I found from 6 to 9, or an average of 7·1 bristles; ten males of 12–13 millimetres had 8–10, or an average of 8·7 bristles; in eleven males of 14–15 millimetres, the number of bristles varied between 8 and 10, but the average amounted to 9·9; in nine females of 12–19 millimetres there were 8–14, average 10·6 bristles; and lastly, in fourteen females of 20–24 millimetres, from 12 to 17, or an average of 14·4 bristles, were present.*

It would be equally easy to correlate the absence of the tooth at the lower angle of the carapace in the males with their smaller size, if it were not that in females of 13–15 millimetres in length, which consequently do not yet exceed the adult males in size, the tooth is already at all events indicated, and in general even developed to its full size. Under these circumstances the most probable supposition seems to me to be that the 'spina pterygostomiana' first appeared in adult, or nearly adult, females, and in course of time was produced in younger and younger individuals of the same sex. However this may be, we have here a notable exception to the almost universal rule that the males depart further than the females from the common youthful form.

As our *Atyoida* differs in a whole series of peculiarities from the ordinary structure of the Prawns, such as *Palæmon*, *Hippo-*

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* This number of bristles, which varies so much in *Atyoida Potimirim*, has been adopted by Heller in the case of the nearly allied genus *Caridina* among the generic characters; he ascribes to it nine setæ (Heller, *Crustaceen des südlichen Europa*, p. 238).

lyte, *Alpheus*, &c., so are species, genera, and families in general usually distinguished from their relatives and ancestors by numerous characters and not by a single one. And just as we can generally recognize no causal connexion between these various characters, so also in the case of *Atyoida* we should scarcely suspect anything of the kind,—for example, between the structure of the chelæ, that of the posterior maxillæ and the different armature of the carapace in the two sexes, had we only anatomized the dead animals. But so soon as we observe these little prawns living in all their activity, their mode of feeding at once explains the structure of their chelæ and buccal organs and their residence on plants, and this, again, the many-clawed fingers of their walking feet; we see how, as the structure of the chelæ renders them unsuitable for the cleansing of the branchial cavities, the form of the posterior maxillæ, which become adapted to this office, and the altered position of the first pair of swimming feet, come into connexion; the unarmed condition of the males enables us to understand their smaller size, and this again, the youthful structure of their carapace, &c. &c.; in short, all their manifold peculiarities at once come into the closest relation to one another, and we may hope that in many other cases, also, by careful observations of living animals, many apparently unconnected structures, for which at present a mysterious correlation of parts is made responsible, will come to be recognized as reciprocally causative results of Natural Selection.

THE MODE OF ACTION OF FACETTED EYES.

BY PROFESSOR SIGMUND EXNER.*

IT is generally known that the organ of vision in the animal kingdom has been morphologically developed in two directions: in one direction to the eye of the vertebrate, in the other to the facetted eye. Quite recently, Grenacher's anatomical investigations have led to the discovery of the common starting-point of these two developmental forms, and to the tracing from it of the foundation of this sensory organ.† That the optical part of the eye of a vertebrate throws a picture of the objects in the outer world upon the retina, has long been known, and it may be demonstrated in the eye of any albino rabbit; that this picture has a physiological significance may be affirmed with certainty, for those rays, and only those rays, which produce a point of the retinal picture are those which lead to the perception of the corresponding points of the object. The picture is reversed.

Affairs are more complicated in the case of the facetted eye. Johannes Müller‡ was the first to assert that this eye also has a retinal picture, and that it is erect. The mode in which it is produced may be explained as follows:—If we imagine the insect eye deprived of the exquisite transparent structures, the cornea and crystalline cone, it may be conceived as a segment of a rather thick, hollow sphere, consisting of a pigmented mass, pierced by numerous close-set perforations running towards the centre of the sphere. If we further imagine the inner surface of the spherical segment coated with a membrane, it is clear that a picture of external objects must be produced upon the latter. Thus, as through the above perforations, only those rays can reach the membrane which run in, or nearly in, the axis of the perforation, the portion of membrane which closes the perforation within can receive light only from a very limited direction. This direction is different for each perforation. If we draw the rays for the individual points of the object which run in the axis of the perforation, we see that they must produce an erect picture of it upon the supposed membrane. In reality, however, no membrane, in the ordinary sense of the word, is stretched over the inner apertures of the perforations, but the nervous elements, which in combination certainly form the retina, are implanted in the inner parts of the perforations.

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* *Biologisches Centralblatt*, Juhrg. I. p. 272.

† *Untersuchungen über das Sehorgan der Arthropoden*, Göttingen, 1879.

‡ *Zur vergleichenden Physiologie des Gesichtssinns*, Leipzig, 1826.

From this we see at once that the facetted eyes of the two sides of an animal must command nearly the whole space around it; for each eye, by means of its curvature, commands more than the half of all possible directions, and the two eyes, in consequence of their position, reciprocally complete each other. A portion of any object at any time in the field of vision is simultaneously seen by both eyes. We see further from the imaginary picture above given, that the retinal picture, when compared with that of the vertebrate eye, will leave much to be desired in the matter of sharpness; that the sharpness will increase with the number of facets that come on the hemisphere; but that the strength of illumination of each retinal element will diminish as the number increases.

As regards the corneal facets and crystalline cones, these, according to Johannes Müller, produce no change in the nature of the eye, but rather serve only to increase the brightness of the whole picture.

This was the position of matters until the year 1852. Gottsche* then remarked that in the eye of a fly which had been freed from pigment by means of a cataract needle, a great number of minute pictures of external objects, showing considerable sharpness, could be detected under the microscope.† Each of them was situated over a facet of the cornea (the light coming from below towards the convexity of the cornea). These pictures were reversed. Gottsche thought at once that he had discovered the analogy with the eye of the vertebrate; each facet produced a retinal picture just like the vertebrate eye; but man had only two, and the fly several hundred eyes. A note of Johannes Müller's, appended by him to Gottsche's Memoir, appears to have been drawn up as if he agreed with Gottsche's ideas. In subsequent years a great number of authors, and among them Leydig‡ and Max Schultze,§ gave up

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* Müller's *Archiv*, 1852.

† These pictures were previously known to Leeuwenhoek.

‡ *Das Auge der Gliederthiere*, 1864.

§ *Untersuchungen über die zusammengesetzten Augen der Krebse und Insekten*, Bonn, 1868.

Johannes Müller's theory of 'mosaic vision,' and, adopting Gottsche's interpretation, regarded each facet of the compound eye as an independent, perfect eye, possessing its retina and retinal picture.

In 1871, Boll,* chiefly supported by anatomical facts, first suggested a return to the old Müllerian views. He had remarked that, under favourable circumstances, small pictures of external objects can also be obtained through the rods (bacilli) of the retina of the newt, and his attention was then called to the physiological insignificance of such pictures. In point of fact, every fat-globule under the microscope shows comparatively sharp pictures.

Grenacher, who had published a preliminary statement of the results of his investigations in the *Göttinger Nachrichten*,† also opposed the interpretation of the facetted eyes in Gottsche's way, which had become general, and expressed himself in favour of Müller's theory. A year after the appearance of this preliminary statement, and unfortunately without any knowledge of it, I subjected the prevalent theory to a critical examination of a more physical character,‡ by studying the optical properties of a special example, the eye of the *Hydrophilus piceus*. It appeared to be exceedingly questionable whether the picture, which was supposed to be a retinal picture, was at all to be regarded as such optically; and further, that this picture, and especially that of the fly which Gottsche studied, does not exist at all during life. It is produced only when the crystalline cone is removed, and this was done by Gottsche. During life, when the crystalline cone lies behind the corneal facet, it cannot be produced.

On the contrary, I showed that the corneal facet and crystalline cone provide in the most remarkable manner for the bringing together, at the bottom of the crystalline cone, of a comparatively large number of the rays issuing from that point of the object that lies in the axis of a facet. The corneal facet acts in this case as a lens; and the crystalline cone by total reflection, as a catoptical apparatus. The rays which penetrate into it nearly parallel to its axis are, as it were, caught and conducted by reflection to its apex. Other rays, which enter at greater angles, may in part, by repeated reflections be rejected again without reaching the apex of the cone; part of them will pass the walls of the cone and be absorbed by the surrounding pigment, seeing that, at each reflection, the angle under which they strike the surface of the cone becomes greater.

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* *Du Bois-Reymond und Reichert's Archiv*, 1871.

† 1874.

‡ *Ueber das Sehen von Bewegungen, und die Theorie des zusammengesetztes Auges, Wien. Akad. Sitzungsb.* 1875.

Endeavours to test the correctness of this view failed at first, owing to the impossibility of placing under the microscope crystalline cones and corneal facets of an eye in the normal position and under conditions corresponding to those of life. Nevertheless, this test could be carried out at least upon one animal, and it perfectly confirmed the above view. In the southern glow-worm (*Lampyris splendidula*) the crystalline cones are amalgamated with the corneal facets. If this eye is separated, completely freed from pigment by a hair-pencil, then laid with the corneal surface upon a perforated mica object-carrier so that the cornea closes the perforation, and then a drop of the beetle's blood is placed in the hollow of the eye, and over this a small film of mica, we have imitated as exactly as possible the natural conditions as regards refraction and reflection. If we then look down through the microscope upon this preparation,* we see an absolutely black surface, sprinkled with very bright points. The effect is so striking that one cannot help thinking that the object has not been freed from pigment. But if we turn it so that the light may fall perpendicularly to the axis of the cones, these are seen, like the corneæ, to be quite glassy and transparent, and perfectly free from pigment. This experiment shows, in fact, that the rays penetrating into the eye are guided by refraction and reflection to the apices of the crystalline cones; and that, if we leave out of consideration the small amounts that may return through the cornea, these are the only points in the whole optical system from which they can issue. There is nothing in the shape of a retinal picture in Gottsche's sense.

Although it may be hoped that Gottsche's theory is for ever disposed of, and that of Johannes Müller reinstated in its rights, a new question arises out of this very circumstance, namely, how are we to explain the fact that two sense-organs, developed for the same outward purpose, show such differences of structure as occur in the eye of the vertebrate and the facetted eye?

Upon this subject I have also set up an hypothesis. While making some physiological investigations upon the seeing of movements which, of course, related to the human eye, it struck me that the facetted eye was much more advantageously constructed for this special purpose than the vertebrate eye. From the important part performed in the animal world by the seeing of movements (the evidence of this is in my original memoir) it seems really not improbable that in it we have the clue to the comprehension of the insect eyes. This is the state of the case. Let a very small, bright point move before the eye of a vertebrate; the latter will observe the movement, for the retinal element (I take only one for the sake of simplicity), upon which the picture of the bright point first lay, loses its excitation, and in place of it the next one is excited, then, again, its neighbour, and so on. It is otherwise in the facetted eye. The structure of this is such that the light of the bright point penetrates into a whole group of facets, although in different quantities. The nerve-element of that facet, in the axis of which the bright point is situated, is most strongly excited; the neighbouring facets lying in a circle around this receive less light: the circle in contact with these externally still less, &c. If now the bright point moves, the excitation changes in all these facets, increasing in the one half and diminishing in the other. Hence such a movement will be a more striking phenomenon for the facetted eye than for the vertebrate eye. What is shown here in the case of a point of course applies to any moving object.

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* Of course the plane mirror of the microscope must be employed in order to imitate the natural conditions.

My notion, therefore is, that in the seeing of movements the facetted eye is superior to the eye of the vertebrate animal, but inferior to it in distinguishing objects—that is to say, in acuteness of vision.

A further investigation upon this subject is due to Oskar Schmidt.* In various crustacea and insects this observer found crystalline cones, which are by no means cones in a geometrical sense, but rather bent after the fashion of a horn. This was more particularly studied in *Phronima*. In consequence of this observation Schmidt also turned against Gottsche's conception of the eye, and in point of fact how should a picture be produced by refraction at the bottom of a bent cone?

Schmidt, however, regards his new observations as also incompatible with the other theory. He says: 'Nevertheless "mosaic vision" is also excluded in the case of *Phronima*, for the pre-supposed conditions for "mosaic vision," straightness of the axis of the refractive body, and absorption of the rays which enter laterally, do not occur here.'

I believe that O. Schmidt's interesting discovery contains a confirmation and not a refutation of the theory of 'mosaic vision,' for it is only compatible with this. The straightness of the axis of the cone is not in my judgment a necessary condition of 'mosaic vision,' and the absorption of laterally penetrating rays is not prevented by the curvature of the cone.

Imagine a cone with a straight axis, at the apex of which, therefore, as above explained, the rays which come approximately from the direction *a*, are brought together. If we now cut away the apex, and attach to the cut surface a curved transparent rod, all the rays which previously came together at the apex of the cone would penetrate into the rod, and be conducted further on in this rod, just as light-rays can be carried on in the interior of curved glass rods. O. Schmidt has himself made experiments of this kind. Some light will, of course, in general be lost in this process. This crystalline cone with the rod behaves now exactly like the curved crystalline cones of *Phronima*. Let us suppose that it conveys the light received from the direction *a* to the spot of the retina *a*, and then consider the neighbouring crystalline cone *b*. This may be so placed as regards its first portion and also its corneal facet, that, in accordance with the rules applying to the straight cones, it receives light from the direction *b*, which is close to the direction *a*, and then it will convey this light further on, however circuitous its course may be; and if its termination lies near *a*, it will deposit its light close to this upon the retinal spot *b*. In this way the different directions of space will be represented in the same order upon the retina. All that is necessary, therefore, for the production of a 'mosaic picture' is that each crystalline cone shall serve principally light of a particular direction, and that their extremities shall be placed in an order corresponding to this direction. According to the figures given by O. Schmidt these two conditions are perfectly fulfilled. Whether the light makes a circuitous route in the crystalline cone is a matter of subordinate consequence—nay, even the arrangement of their ends which are turned towards the light is quite indifferent, the direction of the axes of these ends is alone important. Could we seize an insect-eye with long filiform crystalline cones by the retina, and disarrange the individual cones, each with its cornea, as one can disarrange the threads of a tassel, we should obtain a 'mosaic picture,' in spite of all curvatures and the displacement of the free ends, provided always that the first part of the cone, with its corneal facet, had the same direction in space after the displacement as before.

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* *Zeitschr. für wiss. Zool.* Bd. xxx. Suppl.

As regards the absorption of laterally falling rays in the surrounding pigment, the curvature of the crystalline cone may doubtless cause many rays not to be absorbed which would otherwise be absorbed, and *vice versa;* the picture would thus lose somewhat in completeness, but why it should be destroyed is not easy to see.

Last year there appeared a monograph upon the visual perceptions which are performed by the facetted eye, by Notthaft.* The author occupied himself with the question of the sharpness of vision which may be assumed for various insect-eyes from their anatomical structure. As two neighbouring facets include between their axes very different angles in different animals, it is to be expected that this circumstance will correspond to an unequal sharpness of vision, and of course that the sharpness is greater, the smaller the angles. Further, however, I do not think we can go with him in his conclusions, especially as we do not know in how many of the individual facets some sensation is produced by light issuing from the same point. Notthaft gives figures, although with some reserve, which are intended to show the sharpness of the retinal picture of a given object. These have been constructed, however, upon the supposition that rays from one point only excite one retinal element of a facetted eye, a supposition as to which at present we know nothing.

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* *Abhandl. der* Senckenb. naturf. Gesellsch. Bd. xii.

I will here pass over much interesting detail that this Memoir contains, and pass at once to the kernel of it. This relates to the physiological interpretation of the facetted eye, and consists in the belief that by means of this eye the animal is able to estimate directly the distance of objects, just as is possible to the vertebrate eye.

Thus the picture of an object is supposed to diminish in brightness as the object is removed, and indeed the brightness is supposed to be in inverse proportion to the square of the distance. The proposition is expressed for the case of a definite hypothesis, which runs as follows:—'Upon every retinula there falls a cylindrical fascicle or line of light precisely in the direction of the optical axis of the element of the eye. The individual rays of light composing this fascicle maintain strictly the same direction. The portion of the object from which they issue and which occupies a single elementary field of vision, is consequently exactly of the same size for all distances, however different they may be; in fact it is exactly equal to the transverse section of the posterior, pointed, non-pigmented end of the crystalline cone, or to that of the retinula.'

Valuable as such a new point of view may appear for the understanding of the facetted eye, I cannot help protesting against it. Thus I regard the hypothesis which I have quoted above as perfectly unjustified. In the first place, it is not true that under the supposed circumstances the intensity of an illumination striking the retinula diminishes in the proportion of the square of the distance. It rather remains the same at all distances. This at once becomes clear if we go back upon the basis of the theory that light diffuses itself in all directions in rectilinear rays. The idea that lies at the foundation of this theory is, that the individual ray retains the same intensity *in its whole course;* the weakening of the illumination in accordance with the square of the distance is therefore caused solely by the divergence of the rays. According to Notthaft's hypothesis only a single ray reaches each point of the retinula, and this consequently retains the same intensity whatever may be the distance of the object from which it comes; and as the number of rays which reach the retinula is also constant, its whole illumination by the admittedly parallel rays is independent of the distance; just as the variable distances within finite limits of an illuminated body from its infinitely distant source of light, have no influence upon the brightness of its illumination. (A body that is illuminated by the sun, which may be assumed to be at an infinite distance, is, *cæteris paribus*, equally bright, whether I place it on the table or on the floor.)

Secondly, Notthaft's hypothesis must be pronounced unjustifiable, even independently of the above-mentioned error.

In point of fact an optical apparatus which provides that only such light as has strictly the same direction at the optical axis shall fall upon the retinula (the surface of which turned towards the light has a finite extension) is inconceivable. Notthaft must have overlooked this difficulty and has thus been misled to his theory. Moreover, he himself upsets it, apparently without being quite clear about the matter, when, after explaining it, he speaks of the probable purpose of the spherical curvatures of the corneal facets, and on other occasions. Thus he himself demonstrates that both converging and diverging rays may reach the retinula. But as soon as any ray which does not run absolutely parallel to the axis of the ophthalmic element can give rise to the sense of light in it, the whole theory falls to the ground. The exposition which the author gives of the light-separating action of corneal facets is unsatisfactory, for in the example cited by him he overlooks the fact that if the corneal facet acts so as to throw one ray entering parallel to the axis to the right and another to the left wall of the crystalline cone, a ray falling obliquely to the axis must necessarily exist which will attain the apex of the crystalline cone.

I believe therefore that the theory of 'mosaic vision' is more firmly established than ever, and that there are no other data for the comprehension of the two divergent types of eyes than the above-mentioned notion of the superiority of the facetted eye in the seeing of movements. Notthaft has maintained that the insect when it moves, for example, when it flies, notwithstanding the supposed delicacy of its sensations of movement, must have difficulty in finding its true position in space. I think we may in this case appeal to the birds, which, during *flight*, and consequently while all objects must appear to travel *past* them with greater or less rapidity, nevertheless possess a most admirable orientation. In all cases individual movement is a remarkable aid to the estimation of the distances of objects. In the latter connexion it may be mentioned that insects are at least so far superior to vertebrate animals in the estimation of distances, as with their two eyes they can see simultaneously a much larger portion of space.

REVIEWS.

AMERICAN SEAWEEDS.[*]

THIS Report is an attempt to present in a compact and more or less popular form a description of the different orders and species of seaweeds known to occur on the coast of the United States from Eastport (Maine) to New Jersey.

Since the publication of Harvey's classical *Nereis Boreali-Americana*, in the Smithsonian Contributions to Knowledge between 1852 and 1857, comparatively little has been added to our knowledge of the seaweeds of New England, the species recently discovered, with the exception of *Nemastoma Bairdii*, being mostly insignificant in size.

But during the last twenty years the great advance that has been made in the knowledge of the fructification and mode of growth of marine algæ, due to the researches of Thuret, Bornet, Areschoug and others, has entirely altered the bases of classification, and no book giving a good account of the modern views of the systematic arrangement and structure of algæ has, until now, been published in the English language.

The chapter devoted in the Report to this branch of the subject gives, in the short space of ten pages, a *resumé*, unequalled for clearness and masterly treatment, of the present views of the distinctive features of the different groups.

The classification is very similar to that published by Le Jolis in his *Liste des Algues Marines de Cherbourg*, but the Vaucheriæ, together with the Fucaceæ, are placed under the Oosporeæ, and the Bryopsideæ are raised to the rank of a sub-order, while the various families of the Florideæ are all described as sub-orders.

The introductory part contains much information concerning the geographical distribution of Algæ in North America, which cannot fail to be of interest to European algologists. Thus, the marine vegetation above Cape Cod is shown to be of a strongly marked arctic character, being a direct continuation of the flora of Greenland and Newfoundland; within a few miles of this arctic flora, and immediately to the south of that point, where the Gulf Stream diverges to the eastward, the Algæ are of a southern character, insomuch that the Long Island flora has much in common with that of the Adriatic. Between Boston and Eastport all the predominating species are of the Scandinavian type, with the exception of *Agarum Turneri* and *Callithamnion Pylaisii:* these do not occur in Europe. The fact that *Phlœospora subarticulata* and *P. tortilis,* as well as several other plants common in Norway, have not yet been found on the New England coast, indicates that its Algæ have not been exhaustively examined. The absence of any members of the Dictyotaceæ, and of several Florideæ common in England, *e.g. Bonnemaisonia asparagoides* and *Plocamium coccineum,* is very remarkable. The genus Nitophyllum, too, is practically unknown anywhere on that portion of the Atlantic coast; and *Gelidium corneum,* a most variable species found in almost all parts of the world, is only occasionally met with, and then in the form separated by some algologists as a distinct species under the name of *G. crinale.* Of other Algæ, *Fucus canaliculatus, Himanthalia lorea,* the common European *Cystoseiræ,* and *Codium tomentosum,* are wanting, and *Fucus serratus* is very rare. On the other hand, some species, such as *Chordaria divaricata, Spyridia filamentosa,* and *Euthora cristata,* are more abundant on the coasts of New England than in Europe.

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[*] *Marine Algæ of New England and Adjacent Coasts.* By G. W. J. Farlow, M.D. Reprinted from Report of the U. S. Fish Commission for '79. Washington Government Printing Office, 1881.

The influence of warmth on the determination of the character of the flora is well illustrated by the occurrence of the southern species, *Rhabdonia tenera, Gracilaria multipartita, Chondria Baileyana,* &c., in Goose Cove, an inlet dammed up at the entrance and only overflowed at high tides, and surrounded by an arctic flora on both sides, but in which the water is much warmer than that of the surrounding ocean. The plants must therefore have been carried over the dam by the tide, and grown in the cove simply because the water was sufficiently warm, in the same manner that in this country Mediterranean species are seen to be almost confined to sunny, shallow pools, where the water soon becomes of a temperature exceeding that of the deeper pools and of the neighbouring sea. But enough has been said to show the extreme interest of this portion of the work.

The systematic part, which naturally occupies the bulk of the report, is enriched by numerous explanatory notes, which exhibit not only an accurate acquaintance with the habits of the species in their own haunts, but an extended knowledge of the literature of each plant. Although the synonymy is very limited, it is sufficiently full to enable the reader to recognize the plants under the new names, where these have been altered during the last twenty years. In a few cases, but chiefly in those in which the author has not been able to examine living specimens of the plants, the most recent information is omitted; thus *Ectocarpus brachiatus,* Harv., has lately been referred to the genus *Phlœospora* by Bornet, and *Chætopteris plumosa* has been shown by Kjellman to have both unilocular and plurilocular sporangia on special branchlets, sometimes on the same and sometimes on distinct individuals; hence the statement that it has the unilocular sporangia on the ordinary branches must be incorrect, and can only refer to another plant resembling it in appearance, but which differs also in the absence of a distinct cortical layer in the stem.

The analyses of the genera and families at the commencement of each group, as well as the list of works consulted, form a useful addition; and the fifteen plates at the end of the Report, although somewhat crude in execution, will serve to give a popular idea of the structure of the reproductive organs of the different groups. An artificial key to the genera, and a good index, complete a work that bids fair to be as popular on this side of the Atlantic as on the other, since the majority of species described in it are also natives of Britain; and the new classification and the explanatory notes will be an invaluable aid to English and North European students of algology.—E. M. HOLMES.

A GARDEN WILD.*

AT first sight we were inclined to think that the peculiar collocation of the words in the title of this book was simply a piece of affectation akin to that of the ballad-writers animadverted upon by Samuel Johnson,—

'Hermit hoar in solemn cell,
Wearing out life's evening gray,'

he said was an illustration of the style adopted by one of the fraternity of whom Boswell spoke with admiration; and, he added, he wouldn't say 'gray evening,' but 'evening gray' he would think was fine. This idea, however, although it applied in many cases, proved to have no sound foundation,—the 'wild' in the above title turned out to be a substantive, whilst 'garden' took on it an adjective signification; nay, the garden was often dropped altogether and the author spoke of it repeatedly as 'my wild.' One has heard tell of the wilds of America, but what is *a* wild? The fact is that what Mr. Heath describes is a wild garden of wild plants and the mode of its formation,—the artificial reproduction within an enclosed space of a small section of the open country,—and he has performed his task so well that one regrets that he has disfigured his book by its title.

Like so many other people who devote themselves to the promulgation of particular views, our author can see little or no good in practices other than those he recommends. Thus all the ordinary doings of the gardener are condemned *en masse*, except so far as they are directed to the production of food. The topiarian art, the art of topiary as Mr. Heath calls it, which was so highly esteemed among the ancient Romans, and has continued partially in vogue down to our own day, is, perhaps, justly placed at a very low standpoint,—cocks and peacocks, bears, foxes, and other animals clipped out of yew or box, are doubtless exceedingly absurd; but we are not prepared to admit that there is not a picturesque side to some of the other efforts of the topiarian artist.

If topiarianism has gone out, other horticultural practices have come into fashion which meet with very little favour at the hands of Mr. Heath. Bedding out and the formation of colour-beds and ribbon-borders he evidently regards with great contempt, and certainly, when adopted, as one often sees them, as the sole method of treatment of gardens of all sorts and sizes, they are liable to become absurd; but in larger and well-arranged grounds masses of colour are very effective, and Mr. Heath himself must admit that they are by no means unknown in nature. Florists' flowers, double flowers, and, in fact, all garden varieties of plants, are treated from a similar point of view,—all, in Mr. Heath's opinion, are mere monstrosities; and we are left to infer that therefore they can have no beauty in them,—a proposition from which we must beg leave to dissent. In fact, it seems to us that our author would have made his argument quite as strong and more acceptable had he omitted all reference to the 'false taste' of the ordinary horticulturist.

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* *My Garden Wild, and what I grow there.* By Francis George Heath. *Sm. 8vo.* London: Chatto and Windus. 1881.

The true purpose of his book is the exposition of the course to be followed and the pleasure to be obtained in the formation of a wilderness of our native plants. He opens it with the description of a visit paid on a hot summer's day to the garden of a friend, laid out on the most approved modern model, followed by an account of a dream he had when, overcome by the heat and the brilliancy of the place, he dropped off to sleep in the friendly shelter of a handsome pagoda. In this dream was revealed to him in the most approved fashion, the beautiful result that might be produced by devoting a space of ground like that he had been inspecting to the production of a garden of plants in their natural wild state, and with their natural conditions of growth realized as far as possible.

Many of us, no doubt, have dreamt of delights of various kinds, but unfortunately all dreams are not prophetic. Mr. Heath, however, was lucky enough to arrive at the fulfilment of his vision, by acquiring a house with a large piece of ground attached to it which had not been disfigured by any of those horticultural abominations against which Mr. Heath's soul revolts. The previous occupier had simply planted a row of lime-trees round it, leaving the centre an expanse of gravel and turf, with a few shrubs. The presence of a small stream of water was a further advantage. Here, in fact, were all the elements required for carrying out the scheme, and Mr. Heath set to work upon it at once with his accustomed enthusiasm. In this little book we have the history of his proceedings told in his usual pleasant style. We shall not attempt to follow the author through the various details he gives for the guidance of such as may choose to devote the ground at their command, or a part of it, to the formation of a wild garden, but the enthusiasm with which Mr. Heath expounds his doings will no doubt lead many to wish, at any rate, to follow his example. For any one with a taste for botanical studies, no more interesting application of a bit of garden-ground could be suggested.

ILLUSIONS.*

ILLUSIONS are usually defined as sensations produced by a false perception of objects. When these false sensations are immediately detected and not acted on as if real, the person subject to them is considered to be sane; when the illusion, however, is believed to have a real and positive existence, and this belief is not removed either by reflection or an appeal to the other senses, the individual is said to labour under a delusion. These distinctions, so well known to psychologists, are scarcely at all recognized as yet by the popular mind; and it is only through the instrumentality of works such as that which we have now under review, that we can hope to make them more generally understood.

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* *Illusions.* By James Sully. Vol. xxxiv. International Scientific Series. London: C. Kegan Paul & Co. 8vo. 1881.

As expressed by the author, 'Common sense knowing nothing of fine distinctions, is wont to draw a sharp line between the region of illusion and that of sane intelligence. To be the victim of an illusion is, in the popular judgment, to be excluded from the category of rational men.' Yet it must be granted 'that most men are sometimes liable to illusion.' 'A momentary fatigue of the nerves, a little mental excitement, a relaxation of the efforts of attention by which we continually take our bearings with respect to the real world about us, will produce just the same kind of confusion of reality and phantasms which we observe in the insane.' The term is used by the author in a wider sense than is usual with psychologists, and made to 'include under it errors which do not counterfeit actual perceptions.' For instance, by this popular extension of the term, a man is supposed to be 'under an illusion respecting himself when he has a ridiculously exaggerated view of his own importance;' and in a similar way of being 'in a state of illusion with respect to the past, when through frailty of memory he pictures it quite otherwise than it is certainly known to have been.'

The distinction between illusion and hallucination, or the sensations which are supposed to be produced by external impressions, although no material objects act upon the senses at the time, is not considered by the author to be very important; since in 'many cases it must be left an open question whether the error is to be classed as an illusion or as a hallucination.' Still, and we think wisely, 'the distinction is kept in view, and illustrated as far as possible.' Illusions are classified under the following heads:—Of Perception, Dreams, Illusions of Introspection, Errors of Insight, Illusions of Memory, and of Belief. The reader cannot fail to meet with much to interest him under each of the above heads. In the last chapter, entitled 'Results,' we are told that the study of illusions 'has tended to bring home to the mind the wide range of the illusory and unreal in our intellectual life;' but it is satisfactory to find further on that 'no doubt its grosser forms manifest themselves most conspicuously in the undisciplined mind of the savage and the rustic.'

A DICTIONARY OF CHEMISTRY.[*]

THE first volume of this work was published in 1863, or about eighteen years ago, and the concluding part of the Third Supplement now before us brings the record of Chemical Discovery down to the end of the year 1879, including the more important discoveries which appeared in 1879 and 1880. Among the important articles in this final portion of the eighth volume are those on Gallium, Gases, Glycerine, Gold, Granite, Guano, Gypsum, Heat, Hornblende, Hydrocarbons, Iodine, Iron, Isomerism, Lead, Light, Magnetism, Manganese, Mercury and Mercury Compounds, Meteorites, Methyl and Methyl Derivatives, Mica, Milk, Molybdenum, Napthlenes, Nicotine, Nitrifications, Nitrates, Oils, Olivine, Organic Compounds, Paraffin, Petroleum, Phenol, Phosphorus, Phosphates, Platinum, Pyroxene, Resin, Selenium, Serpentine, Silver, Soda, Spectral Analysis, Starch, Sugars, Sulphides, Sulphur, Sulphuric Acid and Sulphates, Tellurium, Thermodynamics, Tin, Titanium, Toluenes, Trachyte, Tungsten, Vanadium, Vapour-Density, Volcanic Products, Yttrium Metals and Zeolites.

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[*] *A Dictionary of Chemistry and the Allied Branches of other Sciences.* Supplement. Vol. III., Part 2. By Henry Watts. Longmans & Co.

Chemical research has been unusually active during the eighteen years this Dictionary was in course of preparation, and has resulted in such a mass of facts that in order to record them fairly it has been necessary to extend the work to over ten thousand five hundred closely printed octavo pages.

The time which has elapsed since the appearance of the first volume has also necessitated the addition of various comprehensive supplements, since, in order to bring down the information to date, three or more successive articles on the same subject have sometimes been required. In no case, however, has the same matter been reprinted, and consequently by taking the various articles in the order of their sequence, the student has laid before him a continuous history of the subject under cousideration.

Dr. Watts has performed his task with great care and industry, and has produced a work, which, furnishing, as it does, a complete epitome of the science of which it treats, should be accessible to every advanced student of chemistry. This work is not, however, entirely free from slight blemishes, among which may sometimes be observed evidences of careful compilation rather than of the exercise of an intelligent discrimination with regard to the relative values of the different processes described.

As an example of this want of appreciation, attention may be directed to the article Silver, in which we are told that two methods are employed for the removal of that metal from solutions obtained by the lixiviation of burnt cupreous iron pyrites, namely, Claudet's process, which depends on the almost complete insolubility of iodide of silver in solutions of metallic and alkaline chlorides, and Gibbs', which consists of blowing through the copper liquors a mixture of air and sulphuretted hydrogen, when the first precipitate obtained contains a larger proportion of silver than that subsequently produced. The cost and the production of the two processes are represented as being the same, and the student will naturally infer that they are equally valuable.

As a matter of fact, however, Claudet's process is, without exception, universally employed, while the other, although experimentally tried for a short time, was found commercially unsuccessful. Such occasional inaccuracies will doubtless be corrected in a second edition.

THE MICROGRAPHIC DICTIONARY.*

WE are happy to see that after an interval of ten years the *Micrographic Dictionary* has entered upon a new lease of its existence, the first three parts of its fourth edition having just made their appearance. The book is expected to be completed in twenty-one monthly parts. Of a work so well known and so highly appreciated, it is hardly necessary for us to say anything; but for the benefit of such readers as may be unacquainted with the former issues, we may venture to indicate, in general terms, what is the nature of the book.

The main purpose of the original authors, Dr. Griffith and the late Prof. Henfrey was to give, in a series of alphabetically arranged articles, a summary of information necessary or useful to microscopists, especially in relation to the microscopic forms of animal and vegetable life, and those details of minute structure in the larger organisms, for the examination of which the employment of the microscope is necessary. These articles were very copiously illustrated, partly with plates, containing an immense number of figures, mostly coloured, and partly with numerous woodcuts. By the insertion of articles indicating a scheme of classification for the organisms referred to, with numerous cross-references, provision was made to enable the student to work out the objects systematically, thus, as far as possible, combining the advantages of dictionary arrangement with those of a systematic treatise. Further the authors prefixed to their Dictionary a general account of the microscope and its accessories, and of the mode of using them; while in the body of the work they introduced many articles relating to special points connected with the structure or use of the microscope, such as angular aperture, polarization of light, preparation and preservation of objects, test-objects, &c. By a judicious system of bibliographical references appended to each article, the reader was always told where he could find further information upon the subject if he required it; and thus between the knowledge directly conveyed by it, and its indications of other sources of information, the work was rendered a most useful and valuable summary of all matters connected with microscopic studies.

In the second edition, which was just completed at the time of Prof. Henfrey's lamented death, the authors made very great additions and improvements upon their work: many additional illustrations were given, and while the original design was closely adhered to, it was more thoroughly carried out, and the value of the book, which was much enlarged, was greatly increased. The third edition, in the preparation of which Dr. Griffith was aided by Prof. Duncan, in addition to his present assistants, was a still further improvement upon its predecessors; and from the inspection of the few numbers of the fourth which have reached us, it would appear that the author is strictly following out the same mode of treatment. In its present form the *Micrographic Dictionary* may be regarded as an Encyclopædia of minute Natural History, which we heartily recommend as an invaluable handbook to all students, especially to those who, from isolation or other causes, are debarred from access to large libraries.

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* *The Micrographic Dictionary; a Guide to the Examination and Investigation of Structure and Nature of Microscopic Objects.* By J. W. Griffith, M.D., &c., and Arthur Henfrey, F.R.S., &c. Fourth edition. Edited by J. W. Griffith, M.D., &c., assisted by the Rev. M. J. Berkeley, M.A., and T. Rupert Jones, F.R.S. Parts I. to III. 8vo, London. Van Voorst, 1881.

GLASGOW GEOLOGY.*

THIS work consists of a series of sketches and other papers illustrative of the geology around Glasgow, based upon notes of excursions, which appeared in the local journals from time to time. These have now been carefully revised, and in many parts extended, so as to afford a popular and fairly accurate idea of the geological structure and of the principal features of interest which the rocks of the district present.

Within the area described, as shown by the accompanying geological map, the chief strata are of Palæozoic age, with their contemporaneous and intrusive igneous rocks, covered, however, in many places by a considerable thickness of post-tertiary deposits, formed during the glacial period, the effects of which, and the accumulations resulting therefrom, are fully explained in some of the chapters. In the other chapters are described the various subdivisions and characters of the Old Red Sandstone and Carboniferous series, the latter of which with the associated volcanic lavas and ashes form so important a feature of the geology around Glasgow.

This series of excursion-sketches, with the intercalated historical notices, now issued in a collected form, will be an especially useful guide to those interested in Geology who may pay a passing visit to the district.

THE MICROSCOPE.†

DR. CARPENTER'S manual of the microscope is so well known, that we need hardly do more than call the reader's attention to the publication of a new and enlarged edition, the sixth that has appeared. The book has now increased to some nine hundred pages, and, judging from an inspection of its contents, the veteran author has used every endeavour to render it as complete as possible. The plan of the work continues exactly the same as in former editions, but an immense quantity of new information has been put into it, both in the portion relating to the microscopic investigation of plants and animals, and in that treating of the structure and use of the microscope and its accessories, and the preparation of objects for examination. In the latter department the activity of microscopists has been of late so great that the task of selecting useful apparatus and processes from the multitude of things recommended with more or less reason in every publication devoted to the interests of microscopists, must have been no light task; and although it is quite possible that Dr. Carpenter may have omitted some details that might put in a claim to notice, his book is in this department wonderfully up to date. We notice many things, especially in the way of apparatus, which seem to have been only just brought before the microscopic world.

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* *Among the Rocks around Glasgow.* By Dugald Bell. 8vo. Glasgow: James Maclose, 1881.

† *The Microscope and its Revelations.* By W. B. Carpente &c. Sixth edition. Sm. 8vo. London, Churchill, 1881.

In this edition some little notice is given to the important applications of the microscope in geological, and especially in petrological investigations; want of space, probably quite as much as the necessity for special mineralogical knowledge on the part of the reader, inducing Dr. Carpenter to cut what he has to say upon this department of his subject very short indeed. Considering the extent to which petrology is pushing into the front of geological research in the present day, one would be glad to see its principles treated at somewhat greater length in such a book as this of Dr. Carpenter's; at the same time, his brief statement, accompanied as it is by references to works in which the student may find further information, is always a step in the right direction.

FLOATING GERMS.*

IN view, probably, of the meeting of the International Medical Congress, which has recently been held in London, Prof. Tyndall has collected, in a small octavo volume, some half-dozen of his memoirs on the floating particles so abundant in the air, and which he has made out to play so important a part in many ways. We have here the full description of those numerous and elaborate experiments which the author made for the purpose of demonstrating the organic nature of some of the constituents of the atmospheric dust, and their influence in producing putrefaction associated with the growth of Bacteria in organic infusions, experiments which have always seemed to us to prove most satisfactorily the thesis which the author had set before him. Indeed, the experiments of Pasteur, which now date back a good many years, would, one might think, have been regarded as conclusive.

Nevertheless, the doctrine of spontaneous generation still retains a certain amount of vitality, and Dr. Bastian especially maintains it with great vigour. This doctrine, and the arguments of its supporters, are discussed at considerable length by Prof. Tyndall in more than one of these papers, and it seems to us that he has fully demonstrated its untenability. The *coup de grâce* seems to be given to all arguments in its favour, founded upon assumed imperfections in the result of previous experiments of its opponents, by the system of 'discontinuous boiling' adopted by the author in the case of certain exceedingly 'obdurate germs,' such as the spores of the hay bacillus, which, 'when thoroughly desiccated by age, have withstood the ordeal' of boiling for eight hours. Prof. Tyndall assumed that these desiccated germs resist the effects of heat by reason of their desiccated condition, and that before developing a crop of Bacteria in any infusion, they must necessarily pass into a soft and plastic state. Accordingly having set aside an infusion, undoubtedly infected by some of the most resistant germs, for ten or twelve hours, he then raised its temperature to the boiling point, and set it aside once more. By a repetition of this process the germs as they successively advanced towards the stage of active development, were caught and destroyed by the boiling temperature 'in the order of their resistance'—in fact, the Professor effected a sort of fractional destruction of them, and by repeating the process a sufficient number of times his infusions were all completely disinfected. 'Not one of them,' he says, 'bore the ordeal;' and the sum of the exposures to a boiling temperature did not exceed a few minutes.

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* *Essays on the Floating matter of the Air in Relation to Putrefaction and Infection.* By John Tyndall, F.R.S. 8vo. London: Longmans, 1881.

We shall not follow Prof. Tyndall into the discussion of what is the most important outcome of these researches into the nature of the atmospheric dust, namely, the germ-theory of disease, to which he naturally devotes a good deal of space in this volume; by many medical men the matter is regarded as settled, and the rest of the profession will probably soon adopt the new faith. Upon all the leading points connected with it the reader will find in this volume an excellent summary of information, besides the details of experimental investigations, to which we have already alluded; and although some of the papers are communicated to the Royal Society, the unlearned reader need not on that account dread being unable to understand them.

BRITISH MARINE MAMMALS.*

MR. SOUTHWELL has published a popular account of the Marine Mammalia which have been found in the British Seas, and, although it contains nothing particularly novel, it will serve to furnish general readers with accurate information, pleasantly communicated, upon a subject of which general readers are commonly profoundly ignorant. Mr. Southwell carefully avoids any display of scientific phraseology, but he describes the general characters of the animals referred to with sufficient exactitude to give his readers a good notion of their appearance, especially in conjunction with the woodcut figures which accompany the notices, and which are generally very fairly executed. The information as to the habits and distribution of the species seems to have been carefully got together and from recent sources, and altogether we can recommend Mr. Southwell's book as a very satisfactory contribution to the Popular Natural History of these Islands.

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* *The Seals and Whales of the British Seas.* By Thomas Southwell, F.Z.S. Sm. *4to. London:* Jarrold & Sons, 1881.

A ZOOLOGICAL ATLAS.[*]

SOME twelve months ago we noticed the appearance of a 'Biological Atlas,' by Messrs. A. M. & D. McAlpine, in which the authors, by means of a series of coloured plates, endeavoured to furnish illustrations of a course of lessons in Biology, following the general treatment adopted by Prof. Huxley, upon whose lectures, indeed, the plan of the work was founded. One of the authors has now commenced the publication of a more extended work of the same kind, the first portion of which, treating of the Vertebrata, contains twenty-four large plates with numerous figures showing the external form and internal structure of a selected series of vertebrate types. We presume the invertebrate groups are to follow.

The author here describes and figures the component structures of six vertebrate animals, and in his selection of the types he has to a certain extent been guided by the consideration that the animals should be easily procurable. Thus of the Fishes we have the Skate and Codfish as examples of Selachian and bony fishes respectively; the Salamander is taken as the type of the Batrachia because, although not a British species, it can easily be purchased; the common Land Tortoise serves as an example of Reptiles, a selection which is hardly a good one; and for Birds and Mammals we have the Pigeon and the Rabbit.

Directions are given for dissecting these various forms of Vertebrates, and the structures brought to light are very clearly shown in the numerous figures. The plates seem to us to be better than those in the former Atlas.

NORTH AMERICAN RHIZOPODS.[†]

NOT long since we had the pleasure of noticing the appearance of an admirable work on the Fresh-water Rhizopoda of North America, by Prof. Leidy, published as a volume of the quarto Reports of the United States Geological Survey of the Territories. Notwithstanding some defects, this treatise was undoubtedly a most valuable contribution to the zoology of the Protozoa, and one can only regret that there is in this country no machinery by the agency of which such books might be enabled to see the light.

There is a proverb which says that a prophet shall be without honour in his own country. The United States may probably constitute an exception; if not, Prof. Leidy may pass as the exception that proves the rule. At any rate his book has received the honour of being summarized in a very neat little octavo volume by Mr. Romyn Hitchcock, who gives, as it were, the skeleton of the larger treatise in a very convenient form for the use of students. In this little work, Mr. Hitchcock has abstracted from Prof. Leidy's work the characters of the various groups, genera, and species, bringing them into the form of short definitions, but adhering, as far as possible, to the language of the original. The genera and species are tabulated. The work seems to have been most carefully executed; and the little book, which consists of only sixty-four pages, including the introduction and index, will form a most excellent and portable handbook, serving in fact in place of those notes which a student of Rhizopods would like to make for himself of such a bulky volume as Prof. Leidy's. The only thing that could add to its usefulness could be a couple of plates of outline figures illustrating the forms of animals described; such figures are always a great assistance, especially to beginners.

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[*] *Zoological Atlas (including Comparative Anatomy), with Practical Directions and Explanatory Text.* By D. McAlpine, F.G.S. Vertebrata. Oblong 4to. W. & A. K. Johnstone, Edinburgh and London, 1881.

[†] *Synopsis of the Fresh-water Rhizopods.* A condensed account of the genera and species, founded upon Prof. Joseph Leidy's *Fresh-water Rhizopods of North America.* Compiled by Romyn Hitchcock. 8vo. New York, R. Hitchcock, 1881.

SCIENTIFIC SUMMARY.

ASTRONOMY.

Recent determination of the Solar Parallax.—Lately there has been published in the *Memoirs of the Royal Astronomical Society*, an account of the final results of the expedition to the Island of Ascension, in 1877, organized by Mr. David Gill, now Her Majesty's Astronomer at the Cape of Good Hope, for the determination of the distance of the Sun by means of heliometer measurements of the distance of the planet *Mars* from a number of small stars in its neighbourhood. The investigation now published is very elaborate, care having been taken to discuss all the probable sources of error, so as to show that they cannot have had any effect on the result.

The final results may be summed up as follows:—

Value of the constant of the solar parallax when only symmetrically placed observations are employed, and certain doubtful observations rejected,—

$$\pi = 8''\cdot778 \pm 0''\cdot012.$$

Value of the constant of the solar parallax when all the observations are employed,—

$$\pi = 8''\cdot783 \pm 0''\cdot026.$$

The mean may be taken as,—

$$\pi = 8''\cdot78 \pm 0''\cdot012.$$

This value corresponds to a distance of the Sun of—

93,080,000 miles.

This value is much smaller than any other important determination that has yet been made, but is confirmed to a certain extent by recent determinations of the velocity of light, taken in conjunction with the best values for the constant of aberration.

Recently M. V. Puiseux (*Comptes Rendus*, March 7th, 1881) has published an account of the results of the observations made by the French observers at the Transit of *Venus*, on December 8th, 1874. The time of the passage of the planet over the Sun was observed by eight astronomers at five different stations, namely, Pekin, St. Paul's, Nagasaki, Saigon, and Kobé, and when these are compared, they lead to a value for the constant of the solar parallax of—

$$\pi = 8''\cdot96 \pm 0''\cdot010.$$

It will be remembered that the results of the English observations, which were founded on the time at which the planet touched the limb of the Sun, and not on the duration of the transit, gave results of little value, for by putting perfectly reasonable but somewhat different interpretations on the descriptions given by different observers, there could be obtained any value of the solar parallax between—

$$\pi = 8''{\cdot}90.$$

and—

$$\pi = 8''{\cdot}75.$$

Mr. Stone has criticised the results given by M. Puiseux (*Monthly Notices*, April 1881), and he is of the opinion that two of these durations, namely, those of MM. Janssen and Tisserand, must be rejected as incompatible with the interpretation placed on them. The remaining six then give a value of the constant of the solar parallax of—

$$\pi = 8''{\cdot}88.$$

The English photographs of the Transit of *Venus* failed totally, as had been predicted by more than one astronomer before the Expedition went out in 1874. The Americans relied on another method of applying photography to this purpose, and they seem to have obtained results of far greater accuracy. Lately, Mr. D. P. Todd, of Washington, has published an account of the results which have been so far obtained. At the three northern stations, Wladiwastock, Nagasaki, and Pekin, eighty-four photographs were obtained; and at the five southern stations, Kerguelen Island, Hobart Town, Campbelltown, Queenstown, and Chatham Island, 131 photographs were obtained. From a discussion of the distances of *Venus* from the centre of the Sun, the value of the solar parallax was found to be—

$$\pi = 8''{\cdot}888 \pm 0''{\cdot}042.$$

From a discussion of the position angle at which *Venus* was situated, there was obtained the value,—

$$\pi = 8''{\cdot}873 \pm 0''{\cdot}060.$$

From both classes of observations the result is—

$$\pi = 8''{\cdot}883 \pm 0''{\cdot}034,$$

corresponding to a distance of the Sun from the Earth of—

92,028,000 miles.

It will be seen, therefore, that the results obtained by these two methods, the Transit of *Venus* and Opposition of *Mars*, give results differing by more than a million of miles, and much remains to be done before the value of the solar parallax, or distance of the Sun, can be regarded as known with any degree of certainty.

In the meantime, other and improved methods of determining this important factor continue to be carried on. Prof. Newcomb is engaged on a new determination of the velocity of light; Mr. Gill is understood to be engaged on preparations for a new determination of the parallax from observations of the minor planets; at Pulkowa there is being made a fresh determination of the time taken by light to traverse the terrestrial orbit, from the data afforded by the observations of the eclipses of *Jupiter's* satellites;

Mr. Neison is engaged in determining the solar parallax from a new class of inequalities in the motion of the Moon; Messrs. Neison and Campbell, by means of a new determination of the parallactic inequality, by a method which is independent of the diameter of the Moon; and Prof. Winnecke, by a method founded on observations of the distance of the planet *Venus* from small stars, when near its greatest elongation.

Jupiter.—The planet *Jupiter* is again coming into a convenient position for observation, and it is probable that during the coming opposition further important contributions to our knowledge of its physical condition will be obtained. The great red spot still remains visible and apparently unchanged, and it crosses the centre of the disk of the planet within a few minutes of the time predicted by Mr. Marth, so that its period of rotation remains unchanged, and is not slowly altering, as was surmised by several observers early last year. White equatorial spots are again visible, having a swifter rotation than the red spot. The dark spots do not seem to be nearly so intense as during the early part of the year.

The Comets.—This year has been a peculiarly fortunate year as far as comets have been concerned, no less than four having been already observed, and two of these comets of considerable brightness.

Comet b, 1881.—This bright comet was discovered in the Southern Hemisphere, and was at first believed to be a return of the great comet of 1807, a view quickly found to be incorrect. In June it made its appearance above the northern horizon, and for some time remained a conspicuous object, having a bright nucleus and a tail of considerable length. Numerous sketches were made of its appearance and the usual evidences of apparent changes were seen, though, from the immense extent of these changes, it is at times difficult to believe that they can be other than optical. From his observations with the polariscope, Prof. A. Wright, of Washington, is of the opinion that the greater amount of the light reaching us from the tail of the comet is merely reflected solar light. Prof. Young, of Princetown, considers, from spectroscopic observation, that we thus have almost overpowering evidence that the gaseous substance of this comet is a hydrocarbon, and in a molecular state corresponding to that at the base of a gas-flame. It is not necessarily at a very high temperature, since the experiments of Wiederman, Hasselberg, and others, tend to show that under certain circumstances gases may become luminous, and give their characteristic band-spectrum at temperatures even below that of boiling water. Indeed, the dynamical theory of gases would show that all gases at any temperature must be, to a certain extent, luminous, and give a spectrum if seen in sufficiently thick strata, whatever may be their temperature, an increase of temperature merely increasing the amount of light coming from any mass of gas.

Prof. Henry Draper, of New York, obtained a number of photographs of the comet,—one with an exposure of $2^h\ 42^m$, showing a very dense nucleus and a tail about 10° long: on this photograph a number of very small stars are to be seen, some shining through the central portion of the tail of the comet. Mr. A. A. Common, of Ealing, also succeeded in obtaining photographs of this comet with his great 37-inch reflector, but with less success, having been unable to employ so long an exposure.

Dr. Huggins has obtained photographs of the spectrum of the comet, and he is of opinion that these photographs show the bands in the spectrum, which are regarded by Profs. Dewar and Livering as proving the presence of nitrogen as well as of carbon. In this case, all these elements, hydrogen, nitrogen, and carbon, may be present in different combinations, such as cyanogen, or prussic acid, in the tail of the comet. If this view be really true, it might lend a terrible significance to comets, and the passage of the Earth through the tail of a comet might have the most frighful consequences to us terrestrial inhabitants.

The nucleus of the comet passed quite close to two stars of tolerable brightness, one on June 29th, when the nucleus passed within 18″ of the star *Radcliffe* 1661, and on July 13th, within 32″ of the sixth-magnitude star, 56 *Tauri*. The intensity of the light of this last star was considerably greater than that of the nucleus of the comet, though, from its superior size, the comet was much brighter to the unassisted eye. This comet continued to be visible until September.

Comet c, 1881. — This comet was discovered by Mr. Schäberle, and gradually became bright, until it was nearly as bright as the preceding comet; indeed, the light of the nucleus seems to have been brighter, but the tail was not so distinct. On August 10th it approached very close to the third-magnitude star *θ Ursæ Majoris*, and to the naked eye the nucleus of the comet seemed as bright as the star, whilst the tail had a length of nearly 10°. The comet has now swept into a favourable position for observation in the Southern Hemisphere. It appears to be moving in a very similar orbit to that of a preceding comet.

Encke's Comet. Comet d, 1881.—This periodical comet has again been observed on its return, it having been discovered on August 25th, by Dr. Hartwig at Strasburg, and Herr Block at Pulkowa; and on August 27th, by Mr. Common at Ealing. It is a faint, nebulous object, about 2′ in diameter, and quite close to its predicted place. Towards the end of October it will probably be just visible to the naked eye.

Cape Catalogue of Stars.—Mr. Stone, late Her Majesty's Astronomer at the Cape of Good Hope, has just completed his great Catalogue of Southern Stars, the result of his ten years' labour at the Cape of Good Hope. It forms a goodly volume and a valuable contribution to this branch of Astronomy. It is understood that it is to be supplemented by a determination of the proper motion of the principal Southern stars.

Resignation of Sir G. Airy, K.C.B.—The most important event in the astronomical world has been the resignation of the Astronomer Royal, Sir George Biddell Airy, K.C.B., F.R.S., his resignation taking effect on August 1st, or nearly on the completion of his forty-sixth year of labour, he having been appointed on October 2nd, 1835. Sir G. Airy will thus have held office for a longer period than any of his predecessors, though only for a few months longer than both Maskelyne and Flamsteed. Sir G. Airy, who came to Greenwich with a distinguished reputation, owing to his numerous brilliant investigations whilst holding the appointment of Director of the Observatory at Cambridge, has not disappointed the expectations which were aroused on his appointment, and during the entire period it has been under his control the Royal Observatory has deservedly ranked at the head

Meridional *Observatories*. It is almost impossible to over-of the long series of observations which have been made under his direction, and carefully reduced with the greatest care, and on a uniform principle, under his immediate superintendence. The Greenwich Observations afford an immense mass of thoroughly reduced observations of the Sun, Moon, planets, and stars, such as do not exist anywhere else, and on which will be founded in the future, as they have been in the past, the greatest improvements in Astronomy.

Apart from the routine work attaching to his duties, first as Director of the Cambridge Observatory and afterwards as Astronomer Royal, and therefore head of the Royal Observatory, Greenwich, the principal astronomical labours which have been successfully undertaken by Sir. George Airy are as follows:—The determination of the long inequality in the motion of the Earth, due to the attraction of the planet *Venus*, and depending for its importance on the fact that every thirteen years *Venus* and the Earth come back to almost the same position with regard to each other. The reduction of the Greenwich Planetary Observations from 1750 to 1831, thus placing an immense mass of observations of the planets, all carefully reduced on a uniform system, at the disposal of the theorist who wishes to improve the tables of the planets by perfecting the theory of their motion. Since 1751, all the observations of the planets made at Greenwich have been carefully reduced on the same system, so that at present a long mass of observations are available, ranging from 1751 to 1881. Before this was done every mathematical astronomer had to reduce the observations for himself, adding most enormous amounts of arithmetical drudgery to his other labours. The reduction of the Greewich Lunar Observations, from 1751 to 1831, and subsequently the extension of this labour up to 1851. This was a still more laborious and important labour than the last. It is true that up to the present time it has not been employed in the manner that might have been anticipated, as Hansen's Tables were not founded on this great work, being partially constructed before it appeared, and no new lunar tables of any importance have since been constructed.

Besides these great works, numerous contributions to the advancement of Astronomy are due to Sir G. Airy, such as the publication of Groombridge's Catalogue of Circumpolar Stars; several expeditions to observe Total Eclipses; the Transit of *Venus* Expedition of 1874; &c. &c.

Mr. W. H. M. Christie, late the principal Assistant at Greenwich, has been appointed the new Astronomer Royal, with Mr. E. Dunkin as his principal Assistant.

BOTANY.

Reproduction of the Unicellular Algæ.—G. Klebs has communicated to the *Botanische Zeitung* (1881, Nos. 18–21) an article on the development of numerous unicellular Algæ, generally grouped as Protococcaceæ. In the forms here described, the development is essentially similar; all of them are strictly unicellular; no vegetative division occurs; each cell lives for itself, and at its period of maturity forms a number of daughter-cells, generally zoospores, each of which of itself (or when a copulation takes place the product of this process) grows into an individual like the parent cell. In external form and internal structure, these Algæ are very similar; the principal differences between them are manifested in the particular features of the development, and especially in sexual fertilization. One of them, *Scotinosphæra parodoxa*, is decidedly asexual, if a two years' cultivation may be decisive upon this point; this Alga possesses a special peculiarity, the structure of the constantly asexual zoospores. The cell, at its maturity, shows a differentiation of the green protoplasm into numerous cylindrical rods; these gradually fuse together, during which process a red plasmatic granular matter is separated. The final result is the formation of a single dark-green sphere in the midst of the red granular matter; this sphere immediately begins to divide again, and by repeated divisions, during which the red matter is again taken up, the asexual zoospores are produced.

The simplest process of sexual fertilization is exhibited by two other Algæ, *Chlorochytrium Lemnæ* and *Endosphæra biennis*. In these the zoospores, which are produced simply by repeated binary division, always conjugate in pairs, which originate from the same mother-cell; only the product thus formed is capable of propagating the species. In *Chlorochytrium*, in the course of the summer many of these sexual generations are successively produced, and the generation first exposed to the influence of winter falls into a resting state; in *Endosphæra*, on the contrary, each generation requires a whole year for its development. This simplest possible form of reproduction by self-fecundation was previously known only in *Actinosphærium Eichhornii*.

A perceptible differentiation of the two conjugating sexual cells makes its appearance in *Phyllobium dimorphum*, which lives during the summer in the leaves of *Lysimachia nummularia*, in the form of green branching tubes. Some of the cells form large, and the others small zoospores, and only the product of the conjugation of a large one with a small one is susceptible of development. Some other peculiarities occur, which show upon how low a grade of development the several phenomena are in these green unicellular Algæ; nay, even their constancy in the same species, or at any rate in very nearly allied forms, is but slight. In the genus *Chlorochytrium*, besides the distinctly sexual species, *C. Lemnæ*, there are other species in which the course of development is otherwise exactly the same, but the zoospores never conjugate; each of them is capable of continuing the species. In *Phyllobium*, also, species are known (one of them is described as *P. incertum*) which are reproduced only by asexual zoospores, and it is interesting to find that the decidedly sexual *P. dimorphum* may also, under certain circumstances, lose its sexuality, and become an asexually reproductive form.

The Algæ described have one biological peculiarity in common,—they do not live in the water but in other plants, some in dead, some in dying, and some only in living parts. The author does not think that these and similar Algæ can be regarded as parasites, but that the plants merely seek shelter within the organisms they infest.

CHEMISTRY.

Ozone as a Cause of the Luminosity of Phosphorus.—Various writers, and especially Joubert, have called attention to the connexion of the phenomena of phosphorescence with ozone. To learn something of the nature of this connexion, Chappuis has studied the effect of ozone upon the luminosity of phosphorus in the presence of oxygen. Fourcroy long since observed that in pure oxygen, at a temperature of 15° C., and under atmospheric pressure, phosphorus is not luminous in the dark. Chappuis now finds that under these conditions a bubble of ozone introduced into the bell-jar produces phosphorescence, though only momentarily, the ozone being destroyed. Moreover, it is not the vaporization of the phosphorus which determines the phosphorescence, but the combustion of this vapour, the entire space occupied by the oxygen at first appearing luminous, the solid becoming so only after all the vapour has been burned by the ozone. Two cylinders, one containing air, the other pure oxygen, were inverted over two dishes containing potassium iodide and starch solution; a fragment of phosphorus was plunged into each gas in contact with the liquid. In the first the phosphorus became luminous, and the solution became blue. In the second neither phenomenon appeared. Whenever the phosphorescence appeared ozone was present; and whenever ozone was absent there was no luminosity. Moreover, the author calls attention to the fact that certain bodies which have the power of promoting this luminosity of phosphorus are precisely those bodies which destroy ozone or are destroyed by it. Oil of turpentine, for example, which is the most active, destroys ozone completely. In a balloon containing air, phosphorus, and turpentine, a bubble of ozone produces light for a second only, the ozone being destroyed by the turpentine, but burning a part of the phosphorus-vapour also. On adding the ozone the luminosity extends throughout the space, and at last the solid phosphorus only remains luminous. Hence M. Chappuis regards the production of the luminosity of phosphorus in oxygen as one of the most delicate of the reactions for ozone, and proposes to employ it in subsequent researches.—(*Bull. Soc. Chim.: Amer. Journ. Soc., August*, 1881.)

A supposed New Metal.—Mr. T. L. Phipson, from some experiments of his, infers the existence in commercial zinc of a new metallic element, to which he proposes to give the name of *Actinium*, on account of certain actinic phenomena of which he assumes it to be the cause. He says that the white sulphide of zinc prepared by precipitating the solution of the commercial metal with sulphide of barium, and washing, drying, and calcining the precipitate, sometimes possesses the curious property of changing colour under the influence of the direct rays of the sun, becoming first brown, and finally slaty-black, in from twenty to thirty minutes, but resuming its white colour when placed in darkness. Contact with air is necessary for the production of the changes of colour, and the intervention of a piece of glass prevents the blackening from taking place. The supposed new metal is characterized by Mr. Phipson as having a white sulphide, rendered black by the reducing action of the solar rays, and becoming white again in the dark by oxidation. (*Comptes Rendus*, August 22nd, 1881.)

New treatment of Sulphur.—MM. de la Tour du Breuil suggest (*Comptes*

Rendus, September 12, 1881) an improvement in the method of separating sulphur from its gangue. The old method was so wasteful, that attempts were made by means of hot air and superheated steam to get rid of its defects, but these processes were not sufficiently successful to get into general use. The authors have tried the principle of raising the temperature of ebullition of water by the presence of a dissolved salt; and for this purpose they employ chloride of calcium, which has the advantage of great cheapness, and is completely inert in the presence of the sulphur and its gangue at 120° C. The bath contains sixty-six per cent of the chloride, and serves for an indefinite period; the apparatus consists of two rectangular troughs, the dimensions of which vary according to the importance of the mine. One furnace serves for both, and they are used alternately, the boiling liquid being allowed, on the completion of the operation (which takes about two hours), to run from the trough used into the other one, which has been previously charged with mineral. The work thus goes on without interruption. The advantages of this process are said by the authors to be,—very cheap extraction of the sulphur from its gangue (five francs per ton), great purity of the sulphur produced, applicability throughout the year,* as there is no production of sulphurous acid, and almost complete extraction, the residue of sulphur in the gangue being not more than 2–3 per cent.

GEOLOGY AND PALÆONTOLOGY.

Mesozoic Rocks in Japan.—Dr. D. Brauns and Dr. E. Naumann have laid before the German East-Asiatic Society, which has its residence in Yokohama, a statement of the evidence that they have respectively obtained as to the occurrence of Jurassic and Cretaceous deposits in Japan. Dr. Brauns cites two Ammonites which he regards as Jurassic; one of them, identified by the author with *Stephanoceras coronatum*, was obtained from the province of Uragawa Gori, on the island of Jezo. Dr. Neumayr remarks that as the specimens show strong constrictions, and a different arrangement of the sutural lobes, the above identification cannot be correct; and from these and other characters he is inclined to think that it is an *Olcostephanus* of the group of *O. Astierianus* or *bidichotomus*. Nearly allied species of this type occur in South Africa (*O. Baini*, Sharpe), Thibet (*O. Scheutei*, Opp.), and Siberia (*O. polyptychus*), and a new species from the Hilsthon of North Germany (*O. Keiserlingi*) is the nearest European form. The second supposed Jurassic Ammonite is identified by Dr. Brauns with *Peltoceras athleta*, but this determination seems to be doubtful. Its origin is unknown; it was found in a worked stone in Tokio, brought from the town of Sendtrú. As the Japanese origin of the first-named specimen is also uncertain, this evidence of the occurrence of marine Jurassic deposits in Japan cannot be regarded as very satisfactory.

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* The Italian law only permits the fusion of sulphur by the 'Calcaroni' during about half the year, from the end of June to the 15th February.

With regard to the presence of Cretaceous rocks in Jezo, the case is different. The statements of Dr. Naumann relate to a series of Cephalopoda collected in that island by B. S. Lyman, including sixteen species, seven of which can be identified with certainty with previously described forms. The evidence thus furnished, and the general character of the species, indicates a close agreement with the fauna of the Upper Cretaceous of Southern India, as described by Forbes and Stoliczka, which includes all the above-mentioned seven described forms. The species from Jezo are as follows:—

Lytoceras Sacya, Forbes.
Phylloceras, n. sp. (allied to *Indra*, Forb.).
  (? *subalpinus*, Orb.).
  Velledæ, Mich.
Amaltheus Sugati, Stol.
Haploceras, n. sp.
  planulatum, Forbes.
  Gardeni, Baily.
Stoliczkaia, sp.
Anisoceras tenuisulcatum, Forbes.
  sp.
  n. sp.
Ptychoceras gaultinum, Pict.
  n. sp.
  n. sp.

According to Baily and Griesbach, this horizon is similarly developed in South Africa; and it would appear that the Cretaceous formation of Sachalin, described by F. Schmidt, is connected with that of Jezo, so that, in all probability, we have to do here with a continuous marine province of the Cretaceous period, surrounding the whole southern and eastern border of the African and Oriental continent.

Of the above species, three, namely, *L. Sacya*, *Ph. Velledæ*, and *Pt. gaultinum*, are cited by F. Schmidt from Sachalin, and the fourth recorded Ammonite from that island (*Haploceras peramplum*, Mant.), is considered by Dr. Naumann to agree with his supposed new species of that genus. (*Neues Jahrbuch*, 1881, Band ii.)

The Oldest Flowering Plants.—Count de Saporta and M. A. F. Marion recently brought before the French Academy of Sciences a joint memoir on the genera *Williamsonia* and *Goniolina*, the most ancient forms of flowering plants of the fructification of which anything definite is known. In *Williamsonia* the trunk bears at its extremity the organs of reproduction, which show two distinct forms, apparently indicating that the plant was diœcious, but in both there is a multifoliate envelope, which acquires a globular form by the curvature of the bracts composing it.

The parts of the envelope of the male flower seem all to stand at the same level: they are elongated, narrowed, and bent towards each other at the apex. Within the envelope rises a conical axis, the base of which is surrounded by a circular zone, with radiating striæ. The outer margin of this zone, when exposed, is found to be covered with a number of very small irregularly hexagonal areas, which seem to represent so many pollen-cells.

This basal zone would seem to represent a sterile and persistent part of the androphore, in which at one time the whole conical body was covered with a felted layer, composed of the filaments and their appendages, reminding one by its position and arrangement of the male flowers of the Reed-mace (*Typha*).

The female inflorescence of *Williamsonia* is furnished with a globular envelope like that of the male flowers, but its bracts are a little shorter. The organ contained in this envelope, and which is certainly deciduous when mature, consisted of a convoluted (?) receptacle of more or less globular form. The central leaves of the envelope, which have remained in place, testify by their thickness and leathery texture to the primitive nature of this formation. In their midst stands the globular conceptacle, the upper parts of which are covered with carpellary areas; and in the lower part of the receptacle we see the fibrous, woody tissue of which the axis was composed.

The remains of the genus *Goniolina*, D'Orbigny, appear as ovate bodies, in the form of cones rounded at the upper end, and borne upon a cylindrical stalk. The surface is covered with very regular hexagonal areas, arranged in spiral lines. The areas are smaller towards the point of insertion of the stalk. These fossils were formerly regarded as Echinoderms, and described as Crinoids under the name of *Goniolina geometrica*. (*Comptes Rendus, May* 23 and 30, 1881; *Kosmos*, 1881, Vol. IX.)

Trilobites.—Some ten years since Mr. Billing and Dr. Henry Woodward announced the discovery of jointed limbs in a species of *Asaphus*, and Mr. C. D. Walcott has since devoted much careful labour to the investigation of the structure of another Trilobite, *Calymene senaria*, of which he was able to obtain a great quantity, in a wonderful state of preservation, from a part of the Trenton Limestone. By cutting thin sections of these Mr. Wallcott has been able to demonstrate the existence in them of regular walking feet, and also to ascertain the number and character of all the limbs, so as to reconstruct the lower surface of the animal. It appears that the Trilobites, from the absence of antennæ, and the nature of the anterior pairs of limbs, belong to the class Pœcilopoda, now represented only by the King-crabs, but that they form a distinct group in the class. They differ from the extinct Eurypterida, as also from the Xiphosura (King-crabs), living and fossil, by the possession of *four* pairs of walking feet surrounding the mouth, and also by the presence *on each thoracic and abdominal segment of a pair of walking feet, furnished with branchial appendages.*

MINERALOGY.

Characters of some important Minerals.—The results obtained by the more exact methods of investigation employed in Mineralogy of late years have led to the change of a considerable number of minerals to systems of a lower grade of symmetry than those to which they had previously been assigned. The classical memoir of Mallard (*Ann. des Mines*, Vol. X. 1876) had a strong influence in this direction. In it he sustained this change for some of the best-known species, and some of those which had been accepted as types of the systems to which they were referred,—such as garnet, vesuvianite, fluorite, apophyllite, zirkon, apatite, beryl, tourmaline, &c. In explanation of cases like those of just named, Mallard suggested the hypothesis that such crystals were to be considered as twins or compound-crystals, so made up as to have a pseudo-symmetry corresponding to a higher grade than that belonging to the individuals themselves.

The question as to the sharpness of the line dividing the crystalline systems from each other, and in many cases as to the system to which a given crystal really belongs, cannot be said to be decided at the present time. It is certainly possible to exaggerate the 'optical anomalies,' and to attribute to them a morphological significance, when they are, in fact, due simply to accidental causes, such as the internal tension produced at the time the crystal was formed. For example, the species boracite, long regarded as a typical hemihedral form in the isometric system, although with an anomalous optical character, which was variously explained, has been referred, by Mallard and others, to the orthorhombic system. Recently, however, Klein (*Neues Jahrb.* 1881) has shown, by the effect produced upon the optical character by heating sections of the crystals, that the peculiarities are probably due to internal tension simply, and that there is nothing which really conflicts with its being referred to the isometric system. Similarly analcite, the common form of which was long held to be a typical example of an isometric trapezohedron, was afterwards referred to other systems by Schrauf, Mallard, Lasaulx, and others, and finally referred back to the isometric system by several mineralogists, who have arrived at the same result by somewhat different methods. Other similar examples might be given.

M. Bertrand, working from the standpoint of M. Mallard, has recently published some interesting contributions to this subject. He shows that the apparently isometric octahedrons of ralstonite exhibit two optic axes, with an angle of about 90°. He has also examined a series of minerals, ranging from the pure lead phosphate, pyromorphite, to the lead arsenate, mimetite; and his conclusion is that while the first is truly hexagonal, and has a negative optic axis, the other is really orthorhombic, and owes its apparent hexagonal form to twinning. A section of mimetite from Johanngeorgenstadt, cut normal to the vertical axis, was seen in polarized light to be made up of six triangles, each having as base the side of the hexagon; the two optic axes make an angle of 64° in air. Between the two extremes there are various intermediate compounds containing both P_2O_5 and As_2O_5, and it is found that as the proportion of As_2O_5 diminishes, the angle of the optic axes also diminishes. Similar results have been obtained by M. Jannettaz. These facts recall the results obtained with crystals of iodide of antimony by Cooke, who proved the existence of a uniaxial (hexagonal) and a biaxial (orthorhombic) variety, of which the latter changes into the former on a slight elevation of temperature. M. Bertrand has also studied several varieties of garnet, and arrived at essentially the same results as M. Mallard. Sections of crystals of aplome, ouvarovite and topazolite show two optic axes, with an angle of about 90°. Ouvarovite is regarded as made up of twelve pyramids, having the faces of the crystal as their base, and their vertices at the centre. The dodecahedrons of aplome and topazolite are explained as formed of forty-eight simple crystals. Further than this, M. Bertrand found it possible to separate the dodecahedrons mechanically into these forty-eight individuals, each one of which is truly biaxial; the fracture-surfaces are smooth and make angles of 60° with the rhombic faces, when the plane of separation obtained is parallel to the side of the rhomb, and of 90° when it is parallel to one of the diagonals. The former fractures are obtained more readily than the second, and it is concluded from this that the union of the four crystals which form together the same rhombic face is more intimate than that of the twelve complex rhombohedral pyramids among themselves. That this is the true explanation of these facts may perhaps be questioned.—(*Amer. Jour. of Sci.*, August, 1881.)

PHYSICS.

The supposed Heating of Ice.—Dr. A. Wüllner has repeated, by means of a modified form of apparatus, some of the experiments described by Mr. Carnelley (see *Pop. Sci. Review* for April, 1881). He finds that *so long as the bulb of the thermometer is completely surrounded by dry ice, its temperature does not reach* 0° C. If the thermometer rises higher, either the bulb is no longer quite covered with ice, or it is surrounded by water together with a thicker layer of ice. In other respects the course of the experiment was exactly as described by Mr. Carnelley. When the bulb becomes partially bare of ice, the thermometer will rise even to 50° before the ice becomes detached, and rapid heating would probably cause it to rise considerably higher. The detached ice, when it comes in contact with the hot glass, dances about like Leidenfrost's drops.

In order that fusion may not take place, the ice must not be too thick, but how thick was not determined. In one experiment the bulb was surrounded by a coating of ice from 1 to 1·5 centimetre thick, and strongly heated by the flame of a Bunsen's burner; the temperature rose quickly to 0°, when fusion commenced, *not on the surface, but in the centre of the ice, and in such a way that the water was forced out through the surface in small drops, like blisters,* and these, on the removal of the lamp, instantly froze. By heating again and again, the same phenomenon was repeated several times.

In a quantitative experiment, 75 grammes of ice were kept under low pressure and exposed to the temperature of steam from boiling water for five hours; no fusion occurred, and 42 grammes of ice were volatilized into the condenser.—*Ann. Chim. Phys.* xiii.; *Journ. Chem. Soc.* No. 226.

ZOOLOGY.

Origin of the Ova in the Hydroids.—The first idea of what is commonly known as 'Alternation of Generations,' was suggested by the phenomena presented by certain hydroid polypes, in which the sexual functions seemed to be performed by special zooids, which, indeed, were often cast free in the medusoid form, so that the distinction into sexual and agamic zooids appeared in these cases particularly clear. Some recent observations indicate that we may have to modify our views as to the phenomena presented by these animals. According to M. Goette, the ova of the *Hydrella* attain their complete development in the stem of the polype; and according to M. Weismann, the several elements are developed in the stem and afterwards passed into the gonophores in *Plumularia echinulata;* and the ova follow the same course in species of the genus *Eudendrium.* M. A. de Varenne (*Comptes Rendus,* 16th August, 1881) adds some further particulars bearing in the same direction. He finds that in *Campanularia flexuosa* the ova occur in the endoderm of the stem before any gonophores have made their appearance, and that they are simply endodermic cells differentiated, the cells being found in all stages of modification. The gonophore is at first a mere diverticulum of the wall of the polype, into which both ectoderm and endoderm pass, carrying with them the cells which have been transformed into ova. The same phenomena were observed in a variety of *Plumularia echinulata* met with at Roscoff, and in *Sertularia pumila.* Thus in these three species in which the sexual generation is represented by permanently attached gonophores, the ova are not developed in the gonophore but in the stem of the supposed agamic generations.

In *Gonothyræa Loveni* the medusiform gonophores do not become detached from the polype; the ova also originate from the cells of the endoderm within the stem, and are carried with the neighbouring tissues into the blastostyle and gonophore, completing their evolution in the undetached semi-medusæ.

In the Tubularian *Podocoryne carnea* and the Campanularian *Obelia geniculata,* which give origin to free-medusæ, M. de Varenne observed a similar sequence of phenomena. He found that in the region from which the medusæ are to bud, ova are produced by the modification of the cells of the endoderm. When the medusæ begin to bud they are at first simple diverticula of the two layers forming the wall of the polype, and the ova are carried with them into young buds; they are at first very small, but are rapidly developed, and attain their maturity after the medusa has been cast off. M. de Varenne sums up his results as follows:—

'We are thus led to conclude,—1. That in the species above cited, in which the sexual generation is represented by gonophores persistently attached to the hydroid polype, or by semi-medusæ, or free medusæ, the ova originate in the interior of the polype itself, and not in these gonophores or medusæ.

'2. That the ova are only differentiated cells of the endoderm, and that in them may be observed all the stages of transition between an ordinary endodermic cell and a fully developed ovum.

'3. That the ova are conveyed into a bud, which is at first only a diverticulum of the wall of the polype; and that this bud enlarges and finally becomes a gonophore destined to be always attached, or a semi-medusa or free medusæ.

'4. If we accept as demonstrated the facts just put forward, the gonophores, the semi-medusæ, and medusæ cannot be regarded as sexual individuals, and consequently it would seem that we cannot assume an alternation of generations in these species.'

Geographical Distribution of the Eared Seals.—Following up the ideas put forward by Milne-Edwards with regard to the influence of marine currents upon the geographical distribution of the Penguins, M. E. L. Trouessart has applied the same principles to the investigation of the Eared Seals (Otariidæ), and his results confirm those arrived at by Milne-Edwards. In the present epoch the Eared Seals, like the Penguins, seem to be native to the Antarctic lands, whence they have spread towards the north. They are conveyed northward on the blocks of ice which the regular currents detach and carry away from the great southern glaciers, and in this way have colonized all the southernmost coasts of both hemispheres. In the west, Humboldt's current has carried them, with the Penguins, as far as the Galapagos Islands, situated under the Equator; but, unlike the Penguins, the Otaries also occur north of the Equator, being found on the shores of California and in the northern part of the Pacific, but M. Trouessart concludes that the northern Eared Seals did not arrive at their present haunts by the direct route, seeing that there is a distance of more than twenty degrees between the Galapagos and their Californian habitat; and further, *those of the Galapagos and California belong not only to distinct species, but to different genera.*

By investigating the currents of the ocean and noting all the stations at which Eared Seals are met with, M. Trouessart arrives at the conclusion that the absence of these animals from the stretch of coast above indicated is due not to the higher temperature of the tropical regions, but to the action of contrary currents. The equatorial current of the Pacific north of the Galapagos, and that of the Atlantic north of the Falkland Islands, are directly opposed to the northward migration of the Eared Seals. In the Atlantic, those which have reached as far as Tristan d'Acunha and then attempted to advance in the direction of the west coast of Africa, have been carried westward by the equatorial current and driven to the coast of Patagonia. The Eared Seals of the Cape of Good Hope have been prevented from advancing along the eastern coast of Africa by the Mozambique current. Hence Eared Seals are absent from the Atlantic Ocean north of the Falklands, and from the whole western part of the Indian Ocean, having only the eastern part of the latter for their migration into the Northern hemisphere.

Having reached the shores of Australia, the Otaries gradually advanced up the western coast, which they still inhabit, reaching in the north to Melville Island, off Port Essington, where at least two species are found. A secondary current, the direction of which is determined by the Monsoon, puts the Indian Ocean in communication with the Chinese Sea, and from April to October, or exactly at the time the Eared Seals come up towards the north, this current flows towards the north-east into the great basin of the Pacific. It must have facilitated the migrations of the Seals, which [illegible] hrough the passages *of the Molucca* Sea, or by the broader and [illegible] he

Straits of Macassar. Once in the Chinese Sea, they would soon reach Japan; and thence, by the help of the great current of Tessan (the 'Black River' of the Japanese), they would easily make the tour of the North Pacific along the shores of Kamtschatka, the Aleutian Islands, and North America, as far as the south of California.

M. Trouessart considers that the genus *Zalophus* furnishes a proof of this migration,—it occurs on both sides of the Equator, namely, at Melville Island, Japan, California, and throughout the northern part of the Pacific.

Currents have probably acted an important part also in the dispersion of other forms of Seals,—thus a species of the genius *Pelagius*, generally considered almost peculiar to the Mediterranean, has lately been detected in the West Indies; and M. Trouessart remarks that the Monk Seal (*Pelagius monachus*) of the Mediterranean is known to pass out through the Straits of Gibraltar and to occur on the north-west coast of Africa, and as far as Madeira and the Canary Islands, so that some individuals of this species may easily have got caught by the equatorial current and carried away to the West Indies, where they have given origin to a new form (*Pelagius tropicalis*).

Macrorhinus is the only genus of true Seals occurring on both sides of the Equator, and Mr. Allen places the starting-point of this type in the Northern hemisphere. M. Trouessart remarks that the genus is only found there now at one point on the Californian coast, while it abounds on all the shores of the Southern hemisphere, and he is inclined to place the head-quarters of the type about the Island of Juan Fernandez, which is now one of their principal stations, and to assume that they were carried by the oceanic currents through a long *détour* by the Polynesian Islands to California.—*Comptes Rendus*, May 9th, 1881.

Mollusca and Vermes.—At the close of an investigation of the embryology of the Pulmonate Mollusca (*Archives de Zoologie Expérimentale*, 1880), M. Hermann Fol indicates certain conclusions at which he has arrived with respect to analogies existing between the Mollusca and Vermes. He regards the larvæ of the Mollusca as comparable only with the cephalic portion of the larvæ of Annelids, or with an entire Rotatorian. The Mollusca are not, in his opinion, segmented animals whose segments have been subsequently fused together, but animals that remain simple and never present even a rudiment of the metameric budding of the Annelids; whilst Rabl considered that there was an analogy between the very young Molluscan larvæ and a worm with three metameric larvæ. In conclusion, Fol remarks how greatly all recent investigations are in favour of the re-establishment of the Linnean class of Vermes. He thinks that the general result of recent embryogenic researches tends to the establishment of three great divisions of animals:—(1) the Vermes, Bryozoa, Brachiopoda, Mollusca, and Echinodermata; (2) the Arthropoda; (3) the Chordonia (Tunicata and Vertebrata).—*Kosmos*, 1881, Band ix.

Olfactory Organs of Insects.—M. Gustav Hauser has investigated this subject (*Zeitschr. für wiss. Zool.*, vol. xxxiv. p. 367), and arrived at the conclusion that the sense of smell in insects is seated in the antennæ. Glass rods moistened with oil of turpentine or acetic acid were presented to a great number of insects, which showed very clearly their perception of these strong-smelling substances, by moving their antennæ and turning sharply round. But when their antennæ had been previously removed, the same insects gave no signs of perception, even when they were placed quite close to the turpentine or acetic acid. Flesh flies, from which the third joint of the antennæ had been cut away, were no longer attracted by the putrid meat, for which they had previously shown great fondness; they flew about as before, but no longer scented the meat from a little distance. Enveloping the antennæ with a thin coating of paraffin produced the same effect.

M. Hauser made an anatomical investigation of the antennæ, and came to the conclusion that 'the olfactory organ consists in insects, *i.e.* in all the Orthoptera, Pseudoneuroptera, Diptera and Hymenoptera, and also in a great part of the Lepidoptera, Neuroptera and Coleoptera,—1. Of a large nerve, originating from the cerebral ganglion and running into the antennæ of these animals; 2. Of a perceptive terminal apparatus, formed of bacillar cells, derived from the hypodermis, with which the fibres of these nerves are connected; 3. Of a supporting or auxiliary apparatus, which is formed by pits or cones filled with serous fluid, which are to be regarded as simple diverticula of the epidermis.'

It was ascertained that the organ was most highly developed in those insects which employ it in seeking after their food. The greatest number of olfactory pits and cones occur in wasps and bees; thus the hive-bee has 14,000–15,000 pits and about 200 cones on each flagellum. The saw-flies have a much smaller number. The flesh-flies and dung-flies also have 60–150 pits on each antenna; while in the flies which live on plants each of those organs has only 2-5 pits. In general the males have the olfactory organs more strongly developed than the females. (*Kosmos*, 1881, Vol. IX.)

The Ink of the Cuttle Fish.—M. P. Girod has communicated to the French Academy (*Comptes Rendus*, 11th July, 1881) the results of an investigation that he has made of the ink of the Cuttle-fish (*Sepia officinalis*). This fluid has no odour, but is of a slightly salt taste, and has an alkaline reaction. Under the microscope it shows, floating in a transparent serum, a multitude of excessively minute corpuscles, which, when put into fresh water, exhibit distinct Brownian movements. M. Girod finds the ink to consist of:—

Water		60 per cent.
Mineral substances . .	8·613	40 „
Insoluble organic matter .	30·536	
Extractive matter . .	0·851	

The *mineral substances* obtained by calcination constitute a pure white ash, which proved to contain lime, magnesia, soda, potash, iron and carbonic, sulphuric and hydrochloric acids. No phosphoric acid was present.

The *pigmentary matter*, after purification by a long series of operations and drying at 100° C., formed a black powder with a greenish metallic reflection, insoluble in water, alcohol and ether, insoluble in acids and in alkalies. Two analyses gave the following amounts of carbon, hydrogen, and nitrogen:—

	I.	II.
C	53·6	53·2
H	4·04	4·02
N	8·6	8·6

Mortality of Fish in the Gulf of Mexico.—Several notices in the *Proceedings of the United States National Museum* describe a very serious mortality that has occurred during the last two years among the fish of some parts of the Gulf of Mexico, near the coast of Florida, and the evidence would seem to show that it is due to some peculiar condition of a belt of water at a small distance from the shore. A Mr. M. A. Moore, writing from Braidentown, Manatee County, Florida, to Prof. Spencer F. Baird, on the 30th November last, gives a general account of the phenomena which had come under his observation. He says that a considerable portion of the coast population of South Florida depends mainly upon a fishing industry carried on by well-smacks of from thirty to fifty tons, in which the fish are conveyed alive to the Cuban markets. Some two years before the date above given, some portions of the water in the Gulf acquired poisonous properties, which caused the death of all the fish that came in contact with it. 'Whenever a smack with a full fare, *i.e.* a full cargo, of fine healthy fish in her well sailed into this poisoned water, every fish would die, and they would have to be thrown away. This compelled the vessel to return to fishing at the loss of a month's hard work.' This very serious state of affairs has continued ever since, sometimes in one place, sometimes in another, the poisonous influence, whatever it may be, affecting certain localities and currents for a time and then appearing elsewhere; but according to Mr. Moore, there was, when he wrote, more of it about the mouth of Charlotte Harbour and off Punta Russa than anywhere else. Where it prevails, the surface of the water is covered with dead fish, and they are often thrown up on the beach in such numbers that the stench becomes intolerable. The so-called 'bottom fish' appear to be more affected by the poison than any others. The grouper (*Serranus nigritis*) and the snapper (*Serranus erythrogaster*) are the principal fish taken by the fishing-smacks, and these, with the perch, kingfish, trout, and other fish that take the hook, are more affected than the mullet (*Mugil lineatus*) and the pompano (*Bothrolæmus pompano*). Numbers of sharks, rays, eels, and catfish, are thrown up dead upon the beach.

By other writers, the noxious water is said to be distinguishable by its colour, which is sometimes brick-red, and it is described as extending for a distance of 200 miles. The cause of this poisonous condition of the water seems to be very obscure. Some people, including the Mr. Moore above quoted, are inclined to believe that it is due to volcanic action at the sea-bottom, or to an escape of noxious gases, or of mineral substances held in solution; and the editor of a local newspaper (*Forest and Stream*) refers particularly to a boiling spring which is said to exist somewhere off the coast. Others suggest the presence of parasitic plants, and in this view Dr. F. M. Endlich, who has made an analysis of the noxious water, appears to agree. Dr. Endlich reports as follows upon the characters of the noxious and wholesome water, the former under A, the latter under B:—

	A.	B.
Specific gravity	1·024	1·022
Solid constituents (total) per cent . .	4·0780	4·1005
Ferric compounds, per cent	0·1106	0·0724
Injurious organic matter	ratio = 3	ratio = 2

The water A contained a large quantity of Algæ and Infusoria. (*Ann. Mag. Nat. Hist.*, September, 1881.)

The Egg-cases and Young of the Mantidæ.—M. C. Brongniart brought with him from Algeria some of the curious egg-cases formed by the species of the genus *Mantis*, and has communicated to the French Academy the results of his observations on their structure and on the hatching of the eggs (*Comptes Rendus*, July 11th, 1881). He says that the structure of these egg-cases (*oothecæ*) differs but little in the different species; they are attached to the branches of shrubs and to stones, and are generally pear-shaped, with the smaller extremity upwards. Externally they appear to be strongly furrowed transversely, and if cut through in the direction of these furrows, show a circular central chamber containing the eggs, surrounded by a sort of frothy envelope. Each egg-case consists of about twenty storeys of chambers, and each of the external furrows represents a storey; each storey of the central chamber is divided into two cells by a thin antero-posterior partition, and communicates in front with the outside world by a sort of flattened neck, the edges of which, in the form of scales, are bent and laid one over the other. Each of the central cells contains about a dozen eggs, so that there are about twenty-four on each storey; and the eggs are arranged symmetrically, so that the portion of the egg which will constitute the apex of the abdomen is towards the outer wall of the case, while the part representing the head is turned obliquely forwards, and the whole of them are brought close together. Owing to this arrangement, the larvæ, when hatched, merely have to push straight forward in order to escape from the case. Each egg is contained in a sort of gummy cell.

In the construction of the egg-case the insect employs its abdomen and elytra. The female Mantis clings to a branch, and then exudes a sort of frothy, somewhat transparent liquid, which it holds up by means of the extremity of its elytra. Of this it constructs the first storey of its egg-case in the form of a spherical hood, the business being effected by the abdomen, which kneads the frothy substance and spreads it in successive layers with the assistance of the cerci. The eggs are expelled from the abdomen together with a small quantity of the frothy liquid, which serves to form the cells in which they lie.

Soon after impregnation, which generally takes place in September, the female builds her egg-case and deposits her eggs, which hatch out in May and June, and each young larva, while still quite soft, advances towards the aperture of its cell in order to issue from it. M. H. de Saussure gives the following account of the emergence of the larva. He says:—'The little larva has now to escape from the cell in which it is enclosed, and, *as it is too weak to make use of its feet*, nature comes to its assistance by means of a peculiar contrivance. The surface of its body is clothed with a chitinous substance, *upon which* are developed some spines directed backward. By giving its abdomen an undulating movement, the spines serving as a support against the walls of the cell, the larva travels towards the operculum in the same way that an ear of rye, by means of its spiny beards, can travel over a piece of cloth which is set in vibration.' M. Brongniart says that the spines are not upon the abdomen itself, but upon the cerci, or caudal appendages, which constitute two large mamillæ. The legs are also covered with spines which assist the larva in its movements. The larvæ of the upper part of the case are the first to issue, although these eggs are the last laid. On escaping from the egg-case, the young larvæ, instead of dropping to the ground, are suspended in the air by means of two long silken threads, attached by one end to the cerci already mentioned, and by the other to the inner wall of the egg-case. In this way, when all have emerged, they form a sort of bunch, and they remain thus for some days until their first moult takes place, when they leave their cast skins suspended from the case. (*Ann. Mag. Nat. Hist.*, August, 1881.)

Rhizopods, Food for Fishes.—Prof. Leidy reports that the young of some of the suckers (Catostomidæ), such as *Hypentelium, Myxostoma,* &c., have been found by Mr. S. A. Forbes, of Illinois, to have the intestines packed with tests of *Difflugia* and *Arcella,* indicating that they fed on Rhizopods. In a slide containing material from the intestines of a young mullet (*Myxostoma macrolepidotum*) from Mackinaw Creek, prepared by Mr. Forbes Dr. Leidy distinguished *Difflugia globulosa* and *D. acuminata;* and in another of the food of *Eremyzon saccata,* he found *Difflugia globulosa D. lobostoma, D. pyriformis, Arcella vulgaris,* and *A. discoides,* besides another peculiar undescribed form. (*Amer. Jour. Sci.*, July, 1881.)

Division of Englypha alveolata.—Prof. Gruber has described (*Zeitschr für wiss. Zool.*, Bd. XXXV. p. 431) an exceedingly interesting process of division observed by him in the fresh-water Rhizopod, *Englypha alveolata* The test of this elegant creature consists of little circular concavo-convex discs, covering the superficial layer of the sarcode-body. Similar little discs also exist in the interior of the body in the neighbourhood of the nucleus When the sarcode-body begins to grow out of proportion to the test, a portion of the contents of the latter protrudes from its orifice, and gradually increases in bulk, and into it pass by degrees the little discs contained in the interior of the body, and group themselves into a structure resembling a fir-cone, which clothes the surface of the protoplasmic process. By the continued increase of the latter the little discs are pushed further and further apart, until this part acquires exactly the form of the original animal, of which there are then two, adhering together, with the orifices of their tests turned towards one another. It is only now that alterations commence in the nucleus, which still retains its original position. First of all, fine granules and twisted lines make their appearance in it; then it becomes extended in the direction of the long axis of the animal, whilst at the same time a distinct longitudinal striation becomes perceptible, in consequence of which the nucleus divides into two nearly equal parts; of these one passes over into the process, where, like the half remaining into the original position, it soon resumes a pale, nearly vesicular appearance. Now by a rapid circular flowing in the sarcode, a mixture of it takes place, the body draws back here and there a little from the test, and finally the two halves separate as two perfect *Englyphæ*. Gruber attaches much importance to the fact that the separate portion grows into a complete animal before the original nucleus begins to divide, and regards this as furnishing further evidence of the correctness of Strasburger's opinion that the true seat of activity in cell-formation is not the nucleus but the protoplasm,—at any rate, as Gruber points out, his observations furnish a fresh proof that the nucleus of the Rhizopod is a typical cell-nucleus. He has since observed a similar process of division in the nearly allied genus *Cyphoderia*.

A New Species of Horse.—The *Annals and Magazine of Natural History* for July contains a translation of a Russian paper, in which M. Poliakof brings forward a mass of evidence in proof of the existence of a hitherto unknown species of horse, not far from Zaisan, in Central Asia. The animal appears to resemble a small domestic horse, of a dun colour; its head is large in proportion to the size of the animal; and the root of its tail is destitute of long hairs for some distance. M. Poliakof names his supposed new species *Equus Przewalskii*, in honour of the traveller who brought the skin to Russia. He regards it as a true horse, and remarks that 'if it were possible to prove that culture influenced the growth of the tail, and that this became more hairy, and the mane longer, under altered conditions of life,' it might be affirmed that 'it was indeed the animal whose ancestors were reclaimed by man in the stone period, the so-called domestic horse of our day.'

Deep-sea Pycnogonidæ.—The 'Sea Spiders,' dredged by the U. S. steamer *Blake*, during the summer of 1880, along the east coast of the United States, have been described by Mr. E. B. Wilson in the *Bulletin of the Museum of Comparative Zoology*. The deep-sea forms here, as elsewhere, are remarkable for their colossal size, compared with those of shallower water, and in a number of forms the eyes (*ocelli*) are either rudimentary and destitute of pigment, or altogether absent; while, on the other hand, in one genus, *Pallenopsis*, the eyes are unusually large. Mr. Wilson specially describes the morphology and innervation of the anterior appendages; upon which he remarks that 'it is easily possible that the external resemblance of a Pycnogonid to an Arachnid are those of analogy only, and have no morphological significance.' This is the more probable from the extreme variability of the three anterior pairs of appendages in position and structure.—*Amer. Nat.*, August, 1881.

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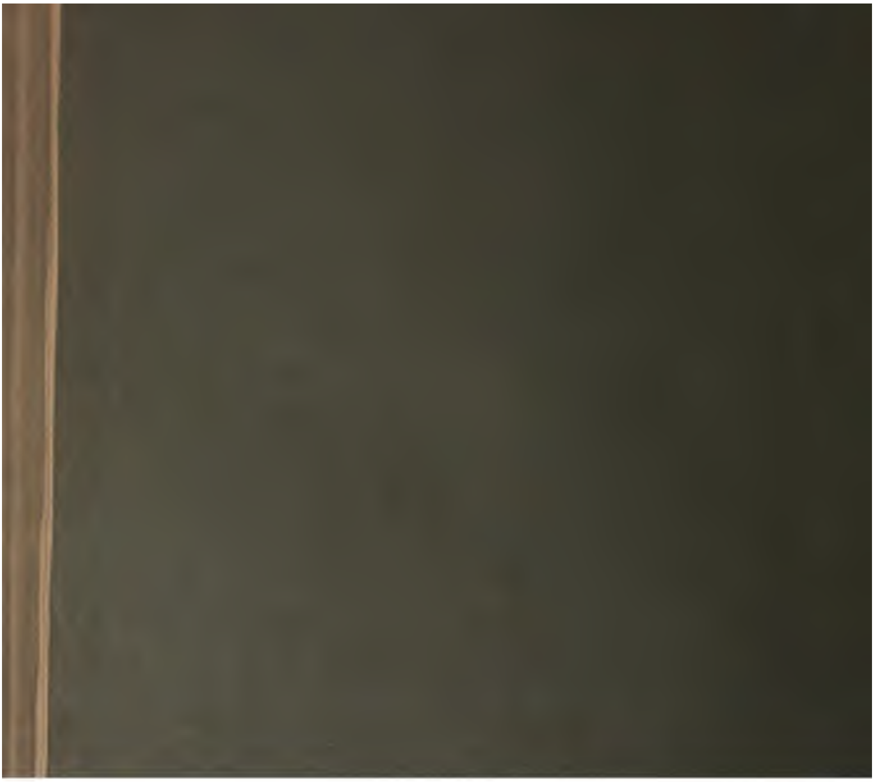

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